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T. B. LITTLE, EDITOR

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Airplane View of
City of Pittsburgh

16th

IRON AND STEEL • EXPOSITION

This coming iron and steel exposition marks the sixteenth under the auspices of the Association of Iron and Steel Electrical Engineers.- Starting in St. Louis in 1919 it has grown steadily until today it is recognized as one of the outstanding industrial shows in this country. Held in conjunction with the annual meeting of the society it has proved to be of immense help to the steel mill engineer as well as the manufacturer of steel mill equipment. For the man in the steel plant it has provided opportunity to view and inspect the latest and most modedn designed steel mill equipment. For the steel mill machinery builder it is a natural medium through which he may market his product. Particularly important is this coming iron and steel exposition. Steel Companies are letting huge appropriations for new equipment by which they hope to realize almost the millenium in operating efficiency. The operating officials, in whose hands rests the responsibility of purchasing this new equipment and superintending its successful operation, will journey to the steel show with the express purpose of learning as much as possible about the newly designed equipment which will be on display.

Among the many varied exhibits will be those of manufacturers of mills, bearings, electric motors and control, industrial trucks, couplings, gears, combustion control apparatus, automatic lubricating devices, lubricants, electrical maintenance equipment, safety devices, quite a few of which will be in actual operation thereby giving the exposition the highest possible interest factor.

It is very gratifying to the Officers of our Association to know that all the booth spaces originally laid out in Hall No. 1 and Hall No. 2 have been taken by over 80 companies who manufacture this type of equipment.

We urge those manufacturers of steel mill equipment who are interested in securing a booth in our 1935 Iron and Steel Exposition that they immediately communicate with our National Headquarters at 1010 Empire Building, Pittsburgh, Pa. for if we receive a sufficient number of such requests we will proceed to take up our option on additional floor area, lay out the booths, sending you full information later.

View of 1934 Iron and Steel Exposition, Cleveland, Ohio

FLAT ROLLED STEEL

The youngest, but most active division of the steel industry is that of the flat rolled section. Particularly alive are those installations of hot and cold strip mills. Among the many factors, from an engineering viewpoint, responsible for the developments of these units have been the four-high mill, improved roll neck bearings and the adjustable speed direct current motors.

Playing no small part in fostering these above advances necessary for the successful operation of wide strip mills, has been the active co-operation of the A. I. & S. E. E. in providing the necessary agencies through which data, information and discussion has been disseminated.

Cognizant of the fact that the society has been greatly responsible for the development of these continuous strip mills, its members have not been totally unaware of the necessity of finding outlets for its use. Still fresh in memory is the "New Uses for Steel Campaign" conducted by the association only a short time ago. It was, as far as we are able to determine, the only movement of its kind made by an organization of steel mill men.

Always anxious to maintain this balance of effort in he'ping the steel industry in both its production and distribution problems, the convention program for our annual meeting September 24, 25 and 26, 1935 will include not only papers on the technical phases but efforts are being made to secure authoritative speakers to discuss the possibilities of absorbing the production of these hot and cold strip mills.

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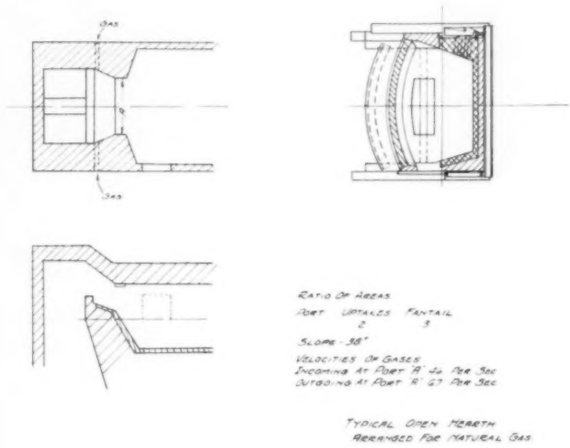
NATURAL GAS IN STEEL PLANTS

By KARL EMMERLING
Asst. Supt., East Ohio Gas Company,
Cleveland, Ohio

Paper presented before the A. I. & S. E. E. Spring Engineering Conference held in Youngstown, Ohio, April 24 and 25, 1935.

Natural gas has been used as a metallurgical fuel in steel plants for at least fifty years. The extent of its use has depended on its price and availability. Twenty-five years ago probably as large an amount of natural gas was used for steel making purposes as is being used now.

For various reasons the use of natural gas was curtailed for a time, and for a number of years the amounts used were not very large. In recent years, however, the interest in the use of natural gas has revived, and at present probably as much is being used by steel plants as ever before.


Ratio Of Areas
Port Uptakes Fantail
2 3
Slope - 38°
Velocities Of Gases
Incoming At Port 'A' 44 Per Sec
Outgoing At Port 'A' 67 Per Sec

Typical Open Hearth Arranged For Natural Gas

There are several reasons for this:

First. A dependable and sufficient supply of natural gas is available in every large steel making center in the United States.

Second. Burners, furnaces, refractories, and control equipment have been developed to such an extent that it is possible to use natural gas economically in the face of the fact that it is generally sold at a higher cost per million BTU than other fuels.

Third. The requirements of steel users as to surface, metallurgical properties, et cetera, have become so exacting that the fuel used for heating determines to a great extent whether or not these requirements can be met.

Fourth. There is an increasing realization on the part of every steel plant operator that natural gas has a certain and very definite place in the steel works heating problems. The price per million BTU is no longer the sole criterion by which natural gas is judged when its use is being considered. Its special values are weighed and taken into account, and very often the steel works manager finds that natural gas at a fifty per cent higher cost per million BTU is the cheapest fuel to use.

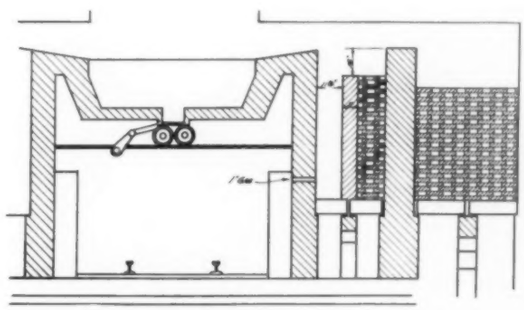
When the use of natural gas in steel plants is being considered, the first question that generally arises is that of its adaptability to open hearth furnaces. To my knowledge, there are at least ten steel plants in the United States that use natural gas for open hearth fuel, either entirely or in part.

Judging from data that has become available from time to time there are certain principles which must be followed in open hearth design if natural gas is to be used successfully, as follows:

1. Slope of the Port Roof. There are at least three open hearth plants where the fuel practice with natural gas is outstanding and perhaps by coincidence the slope of the port roofs on the furnaces in these three plants is almost identical, about forty degrees. In two of the plants the open port construction is used, and in the third the arched over port construction is favored.

2. Restricted Throat of the Venturi Type. The areas in the throat vary somewhat, depending on stack height and checker depth; but in all cases they are sufficiently restricted so that the pressure on the incoming end of the furnace is positive and on the outgoing end, negative.

3. Sealing of Furnace Roof and Walls. In plants where natural gas has been used most successfully, infiltration of cold air into the furnace and checkers has been kept at a minimum by thoroughly sealing all brickwork with insulating plaster.



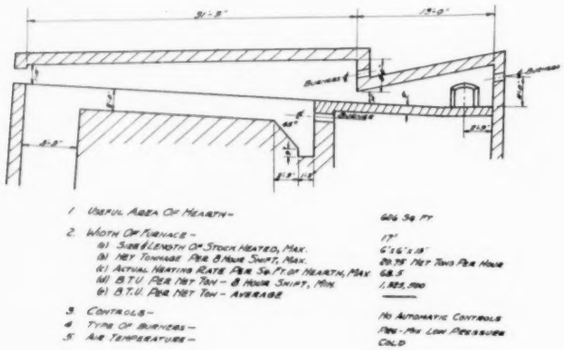
Typical Soaking Pit Arranged For Natural Gas

In order that the proper flame direction be obtained it is essential that restricted throats be used and that air and gas velocities be kept high. Leaky brickwork, particularly at the ends, reduces the pressures and drafts necessary for the successful operation of natural gas fired open hearths, aside from the increased fuel cost due to the chilling effect of the cold air drawn into the furnace and checkers.

4. Increased Weight of Checker Brick. The carry-over of solid material into the slag pockets and checkers is less with natural gas firing than with other fuels and consequently smaller checker open-

ings can be used. This permits the use of a greater number of checker brick and results in a higher per cent of heat salvage.

5. Limitation of Fuel Rate. The plants that have

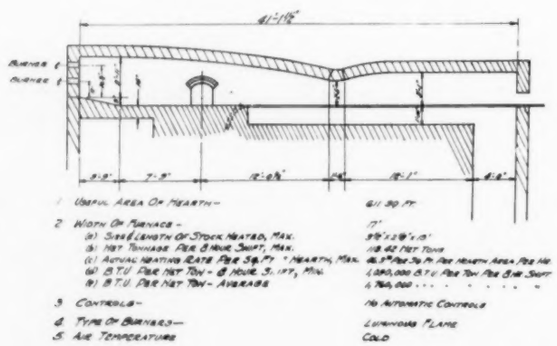


1. Useful Area Of Hearth—	666 Sq. Ft.
2. Width Of Furnace—	17'
(a) Size & Length Of Stock Heated, Max.	6'6"x18'
(b) Net Tonnage Per 8 Hour Shift, Max.	80.78 Net Tons Per Hour
(c) Actual Heating Rate Per Sq. Ft. Of Hearth, Max.	68.5
(d) B.T.U. Per Net Ton — 8 Hour Shift, Min.	1,855,200
(e) B.T.U. Per Net Ton — Average	
3. Controls—	No Automatic Controls
4. Type Of Burners—	Pipe-Air Low Pressure
5. Air Temperature—	Cold

been most successful in the use of natural gas have been those that rigidly limit the first helpers on the amount of fuel used per hour. After a certain optimum rate is reached, additional fuel will not further decrease the time of heat to any extent, but will tend to overheat the roof, thus increasing the rebuilding and repair cost without gaining any offsetting advantage, such as decreased time.

Based partly on personal experience and partly on observation in and information obtained from the various steel works where natural gas is used for open hearth fuel, I feel certain if the foregoing principles are followed that no difficulty should be experienced in obtaining an average fuel practice of from four to four and one-half million BTU per gross ton of ingots in basic open hearth furnaces of the conventional size and design when from thirty to forty per cent hot pig iron is used.

In all plants where natural gas is now being used, the gas is introduced into the furnace through the front and back walls in front of a heel wall which extends across the furnace in front of the uptakes. The air coming up from the checkers sweeps over this wall and carries the gas into the furnace proper. The air and gas mix slowly, and long and highly luminous flame combustion results. The pressure at which the gas actually enters the fur-



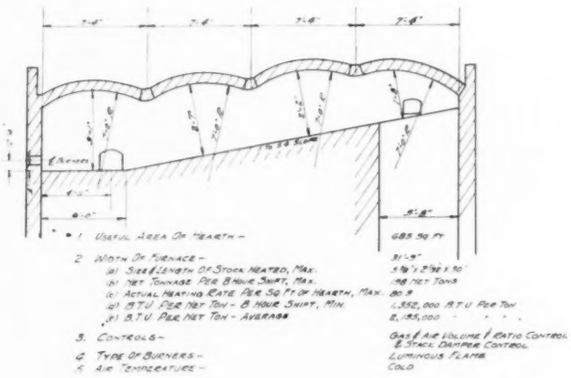
1. Useful Area Of Hearth—	611 Sq. Ft.
2. Width Of Furnace—	17'
(a) Size & Length Of Stock Heated, Max.	5'6"x18'6"
(b) Net Tonnage Per 8 Hour Shift, Max.	118.42 Net Tons
(c) Actual Heating Rate Per Sq. Ft. Hearth, Max.	96.8 Per Sq. Ft. Per Hearth Area Per Hr.
(d) B.T.U. Per Net Ton — 8 Hour Shift, Min.	1,490,000 B.T.U. Per Ton Per 8 Hr. Shift
(e) B.T.U. Per Net Ton — Average	1,760,000
3. Controls—	No Automatic Controls
4. Type Of Burners—	Luminous Flame
5. Air Temperature	Cold

nace is low, usually not more than three or four ounces.

Various attempts have been made to burn natural gas in open hearth furnaces designed for oil or tar firing, and without changing the furnace lines. A gas burner was substituted for the oil burner and flame direction was maintained by using gas at high velocities and properly directing the burner. Gas pressures of from seven to fifteen pounds have been tried. This method of firing results in practically flameless combustion, and the time required for melting down is generally reduced. Difficulties were encountered, however, in finishing the heat, and the time lost in finishing more than offsets any gains made in melting. A luminous flame seems to be necessary for refining or finishing the heat.

It seems as if it should be possible to work out some method of natural gas firing whereby advantage could be taken of the fast meltdown obtainable with end firing. Perhaps in order to get the most out of natural gas it will be necessary to design a furnace in which a combination of end and side firing can be used.

Producer gas is generally considered to be the most suitable fuel for heating soaking pits. Experience shows that natural gas can be successfully used and a considerable reduction in BTU per ton can be effected by proper application of natural gas and by taking advantage of certain of its inherent qualities.



1. Useful Area Of Hearth—	685 Sq. Ft.
2. Width Of Furnace—	31'-9"
(a) Size & Length Of Stock Heated, Max.	8'6"x 2'6" x 30'
(b) Net Tonnage Per 8 Hour Shift, Max.	198 Net Tons
(c) Actual Heating Rate Per Sq. Ft. Of Hearth, Max.	80.9
(d) B.T.U. Per Net Ton — 8 Hour Shift, Min.	1,552,000 B.T.U. Per Ton
(e) B.T.U. Per Net Ton — Average	2,135,000 " " "
3. Controls—	Gas & Air Volume Ratio Control & Stack Damper Control
4. Type Of Burners—	Luminous Flame
5. Air Temperature—	Cold

In most of the natural gas fired pits the gas has been applied as shown in the second illustration. A 9" wall is built across the checker chamber, about 15" from the wall of the pit proper. This wall extends across the entire chamber, and openings to the flues, lying between the pit wall and the 9" wall just described, are closed up. A well is thus formed which is as wide as the checker chamber, 15" across, and as deep as the distance from the bottom of the port to the bottom of the checkers. Gas is introduced into the bottom of this well at fairly low pressures, through one or two pipes, generally 1½". As the area of the well is large when compared with the area of the supply pipes, the velocity of the gas at the mouth of the well is low, and consequently it does not mix completely with the air stream from the checkers at the point where the two meet. Combustion is therefore delayed, and is of the lunminous type, and takes place in the pit proper. The steel is completely enveloped in flame.

Some care must be exercised in choosing the proper height of wall. This height has considerable bearing on the rate at which the air and gas mix and consequently on the speed of combustion.

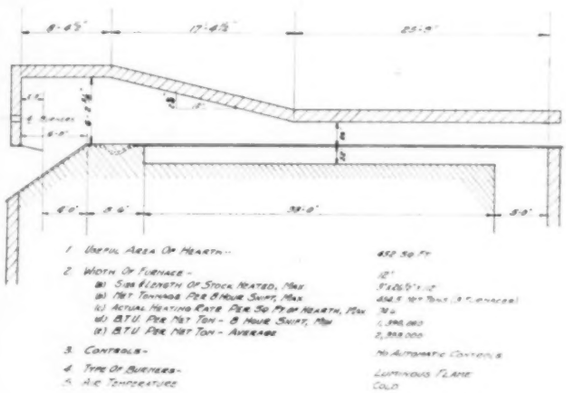
The cost of natural gas per million BTU is gen-

erally higher than producer gas, but this can be offset by taking advantage of faster heatup of cold pits, closer regulation of air-gas ratios, more constant heating rate due to uniform gas quality, and reduced repair costs. In all the pits heated with natural gas that have come to our attention, the gas has been applied in a manner similar in principle to that just described.

Considerable progress has been made in applying natural gas to continuous heating furnaces. As a result, there has been a material increase in the use of natural gas for this purpose.

There has been greater recognition on the part of steel plant operators of the fact that accurate control of fuel and of furnace conditions, such as can only be attained with a clean, high BTU gas, has more bearing on the final cost of the product than the cost of the fuel itself.

In the last two or three years natural gas has replaced other fuels in about thirteen continuous heating furnaces in the steel plants served with natural gas by our Company. The reasons for this change in fuel have been several: (1) The need for better quality; (2) the feeling that natural gas would give a lower fuel cost than the fuel in use; (3) need for more production.



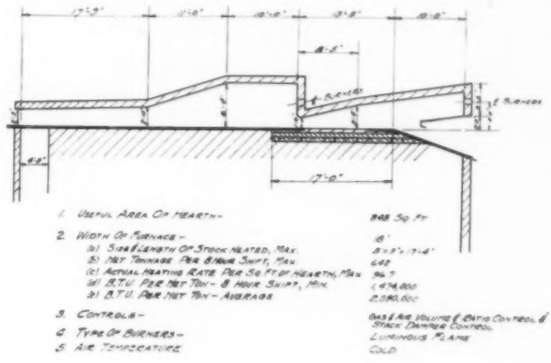
The heating cost itself has not always been reduced, but it is our belief that the final cost of the product has been reduced.

In all the heating furnaces where natural gas has been substituted for other fuels in recent years, the following has been done:

a. Semi-diffusion or so-called luminous flame burners have been used. These burners, as you know, give a heavy, smoky flame. The combustion gases carry considerable free carbon when the air-gas ratios are proper, and due to the delayed combustion, which is a characteristic of this type of burner, the steel heats farther back in the furnace than is the case with premix type burners.

b. Burners are usually kept small in size, and consequently, a fairly large number are used. By adjusting individual burners, the temperature of the billets heated can be kept uniform from end to end, and in case of double row slab heating furnaces, the slabs discharged from one side of a furnace can be kept at the same temperature as those discharged from the other side. It is highly essential in continuous strip mill practice, where slabs are heated in two or three furnaces, and consequently in four or six rows, that they be kept uniform in temperature.

c. Air for combustion, regardless of whether it is hot or cold, is supplied to the burners at from three to five inches of water pressure. Positive control of



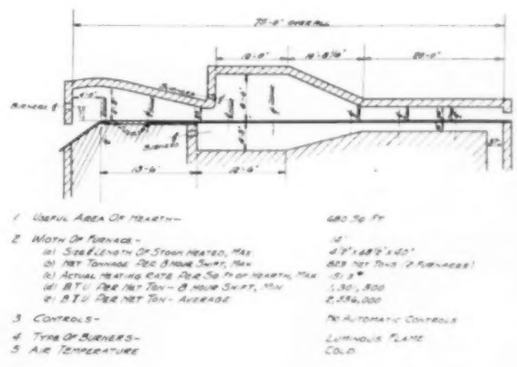
the air cannot be obtained any other practical way, and in order to obtain the best results with natural or coke oven gas, the air for combustion must be subject to positive control.

The use of automatic controls on continuous heating furnaces is becoming more common. Furnace pressure, air-gas ratio, volume and pressure controls, have been improved to such an extent in the last few years that their acceptance is constantly increasing. There are controls on the market that really control, and some remarkable results have been obtained with them on continuous heating furnaces.

One case has recently been called to my attention where the adoption of controls has reduced the fuel cost 33-1/3%, notwithstanding the fact that 30c natural gas was substituted for producer gas at the time the controls were installed.

There is naturally a great advantage in being able to control furnace atmospheres positively and automatically. The quality of the scale has a great bearing on the quality of the steel, and the furnace atmosphere to a great measure determines the quality as well as quantity of scale.

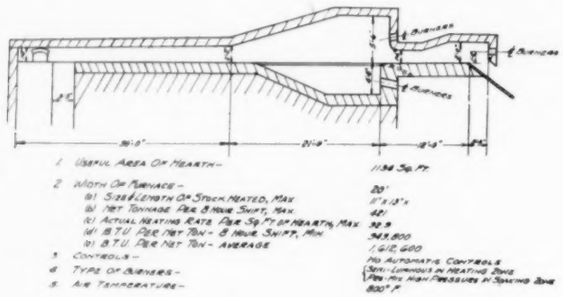
In changing from other fuels to natural gas it is not always essential that furnaces be rebuilt. The



use of proper burners and good controls on the existing furnaces has in many cases given a successful conversion to natural gas.

Of the thirteen furnaces mentioned, three were

entirely rebuilt, two had partial roof changes, and the rest had no major changes made on them. Four were equipped with controls. All of them are performing in an acceptable manner. In this paper are various illustrations showing some of the various types of furnaces that are being fired successfully with natural gas.


1. Useful Area Of Hearth — 1138 Sq. Ft.
2. Width Of Furnace — 20'
(a) Size & Length Of Stock Heated, Max. 17"x13"x
(b) Net Tonnage Per 8 Hour Shift, Max. 481
(c) Actual Heating Rate Per Sq. Ft. Of Hearth, Max. 30.9
(d) B.T.U. Per Net Ton - 8 Hour Shift, Min. 949,800
(e) B.T.U. Per Net Ton - Average 1,612,600
3. Controls — No Automatic Controls
4. Type Of Burners — Semi-Luminous In Heating Zone
5. Air Temperature — 800° F.

In sheet mill heating with natural gas there are no developments in the use of natural gas that are not of common knowledge. Heating of sheet bar and breakdowns both in old style and in continuous furnaces have been discussed before. The use of luminous or semi-diffusion burners on normalizing furnaces is meeting with acceptance and has resulted in production increases and an improved quality of oxide on the sheets normalized.

Real strides, however, have been made in sheet mill annealing. The development of the tube type and radiant tube annealing cover has the potential possibilities of changing the entire picture of the manner in which flat rolled steel is annealed. It is the first real step in the improvement of annealing practice since the now commonly used method was developed.

An annealing department entirely equipped with either of the above types of cover will present a different picture from the one we now see when we walk into an annealing room. It should be one of the cleanest departments in a mill; it will lend itself to straight line handling; handling costs will be reduced to a minimum; the time that the steel remains in the annealing department will be shortened; the uniformity of the product will be improved; and the cost of fuel for annealing will be lowered under any of the older types still in use. The new annealing departments will not be even distantly related to those now commonly used.

In recent years there has been a gradual reduction in the temperature at which sheets are annealed. Consequently, natural gas as it is delivered from the mains has not been able to do an entirely satisfactory job of deoxidizing. Prepared gases of higher chemical activity have been developed, using natural gas as the raw material. The prepared gases, or atmospheres as we usually call them, have resulted in a very much better deoxidized sheet and have reduced the cost of deoxidizing or bright annealing by at least seventy-five per cent. I was recently told by one of the sheet mill operators to whom we sell gas and who has changed from straight natural gas to a prepared atmosphere made from natural gas that the cost of gas for bright annealing has been reduced to two cents per ton.

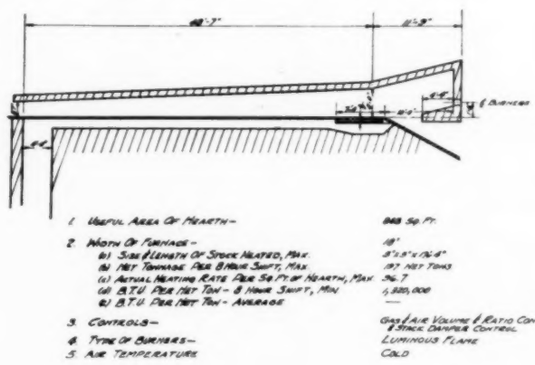
The combination of tube type or radiant tube heating and prepared atmospheres should be the answer to a number of problems which now present serious difficulties in the heat treatment of steel plant products.

Why shouldn't it be possible to bright normalize sheet and strip and thus eliminate the pickling of normalized stock? Why isn't it possible to develop special atmospheres from natural gas that will eliminate decarburization of carbon and alloy steels that must be annealed or otherwise heat treated before they are shipped to the customer?

As I said in the beginning, the use of natural gas in steel plants has increased tremendously. There are at least two steel plants in the United States where natural gas is the only metallurgical fuel used; there is a third one where the same thing will be true very soon, and there is quite a number of plants where at least fifty per cent of all the metallurgical fuel used is natural gas.

Steel plant executives are realizing more and more that natural gas offers certain advantages which should not be overlooked, and it is this realization, together with its almost universal availability, that is making natural gas the coming steel plant fuel.

This remark is often made: "Certainly we would use natural gas in preference to other fuels, if it were


1. Useful Area Of Hearth — 848 Sq. Ft.
2. Width Of Furnace — 18'
(a) Size & Length Of Stock Heated, Max. 8"x8"x (10-4"
(b) Net Tonnage Per 8 Hour Shift, Max. 197 Net Tons
(c) Actual Heating Rate Per Sq. Ft. Of Hearth, Max. 34.7
(d) B.T.U. Per Net Ton - 8 Hour Shift, Min. 1,320,000
(e) B.T.U. Per Net Ton - Average —
3. Controls — Gas & Air Volume & Ratio Control & Stack Damper Control
4. Type Of Burners — Luminous Flame
5. Air Temperature — Cold

as cheap." If the person making the remark means that it should be sold him for the same price per million BTU as say, coal gasified, he in most cases will be doomed to disappointment. Except in very few cases, natural gas cannot be produced, transported, and distributed as cheaply as other fuels; but it generally can be sold at a cost low enough that, when all its advantages are taken into consideration, it will be as cheap as, or cheaper than, the competing fuels.

It is hardly necessary to talk about the advantages that natural gas has over other fuels. All of you know and admit that such items as controllability, freedom from dirt, tar, etc., absence of sulfur compounds, pressures, high enough to meet any ordinary burner requirements, longer refractory life, etc., all have a real value to the steel maker and that in no other fuel than natural gas can he find all the qualities that create that value.

You know that the fairly constant quality and the ease with which fuel-air ratios can be maintained have a decided influence on the quality of the finished product.

I am sure that most of you feel that due to some of the foregoing reasons the amount of scale formed in steel plant heating operations is lower when natural gas is used than it is with other fuels. I have tried hard to obtain figures to support that feeling, but, due to the nature of the problem of determining actual scale loss in the furnace, there just seem to be no dependable figures available.

In addition to the above commonly accepted advantages of natural gas, there are two others not ordinarily considered.

1. What is it worth to a steel company to have natural gas in quantity, and at the correct price, available for use? If you were going to choose a site for a new steel works, how much more could you afford to pay for it, all other things being equal, if natural gas were available? What value does the presence of natural gas have when plant changes are being considered? I don't know how to evaluate this, but perhaps some of you can.

2. My personal idea of an ideal steel plant is one where the only metallurgical fuel used is natural gas. While this might be ideal, I realize that in most cases it is beyond attainment. The presence of coke oven gas and blast furnace gas prohibits it. The next best and perhaps the most practical thing is mixed gas, of a sufficiently high heat value to keep the initial investment in the distribution system within reasonable limits.

The idea, of course, is to make this mixed gas the one and only fuel to be used in the heating operations of the plant. Without natural gas, such a fuel policy cannot be carried to completion, as I do not believe that any well integrated steel works has sufficient coke oven gas available to make a complete conversion of steel plant heating operations to high BTU gas firing possible without natural gas.

It seems to me that any steel plant that goes over to complete gas firing has reduced its fuel difficulties to a minimum. You all know the problems that are connected with fuel storage, handling, processing, and maintenance.

With natural gas as an adjunct, some of these will be eliminated entirely and others will be minimized to the lowest degree. An efficient mixing station, good gas boosters, a well designed and adequate distribution system, and the proper automatic control devices on the furnaces should bring the problems arising from the utilization of fuel down to an irreducible minimum.

DISCUSSION

Discussion presented by

F. B. Jones, Director, Industrial Gas Sales, Equitable Gas Company, Pittsburgh, Pa.

H. V. Flagg, Combustion Engineer, American Rolling Mill Company, Middletown, Ohio.

A. J. Boynton, Vice President, H. A. Brassert & Company, Chicago, Ill.

J. L. Miller, Asst. Chief Engineer, Carnegie Steel Company, Youngstown, Ohio.

K. Emmerling, Asst. Gen. Supt., East Ohio Gas Company, Cleveland, Ohio.

F. B. Jones: I was very much interested in Mr. Emmerling's paper, as I, too, represent one of the natural gas companies. My company furnishes gas service in the Pittsburgh district. As Mr. Emmerling said, all the natural gas companies have a dependable and a reliable supply of gas. I, personally, feel that there are splendid opportunities for co-operation between the steel companies and the gas companies on fuel matters. You need a clean, controllable, and uniform fuel for many of your heating operations, and we have just such a fuel service to offer. Our business, on account of its nature, has certain limitations and restrictions that we must observe. On the other hand, we recognize that in the selection of fuels for your operations, you must be guided by fuel economies. However, from the natural gas company's point of view, we believe there are many opportunities for us to supply your fuel requirements with mutual benefit to your companies and the gas companies. I believe the greatest need is for the steel companies and the gas companies to recognize each other's problems and limitations and to put "all the cards on the table" in terms of the vernacular.

H. V. Flagg: Mr. Emmerling has given us examples of utilization of natural gas in open hearth furnaces, soaking pits, reheating furnaces, and some general applications. We have men here who are qualified to discuss each of these applications authoritatively. We would like to have some of these gentlemen comment on this paper.

A. J. Boynton: At the risk of repeating myself, I want to call attention to the fact that many of the furnaces which Mr. Emmerling has described, were provided with means of automatic control of fuel flow, fuel-air ratio and furnace pressure. Under these circumstances, the heating has not only been economical from the standpoint of fuel cost but it has been particularly satisfactory from the standpoint of the character of scale formed on the steel. This scale has been tight and yet easily broken and removed, so that the resultant product has met rigid specifications as to surface. As engineers interested in fuel and combustion, it is perhaps natural that we should stress too greatly the fuel economies possible to achieve by a given method of construction or operation, or a certain fuel. Practically the ability to conform to rigid present day specifications is of, at least, as much value and usually more important than is any reduction in fuel cost.

The furnaces which Mr. Emmerling has described have, in those cases with which I am familar, given exceptionally good service in both these respects.

J. L. Miller: I don't think there is much argument about the desirability of using natural gas. I think we would all like to use it if we could get it right. By right I mean the cost per million B.T.U. in the furnace. The gas companies in offering natural gas as a fuel for slab and billet heating furnaces

(Continued on page 372)

MAINTENANCE OF ROLL NECK BEARINGS

By H. D. ROBB
Pittsburgh District Manager, Industrial Division,
The Timken Roller Bearing Company

Paper presented before the A. I. & S. E. E. Spring Engineering Conference held in Youngstown, Ohio, April 24 and 25, 1935.

Maintenance is ordinarily thought of as being strictly the work done by the department under the control of the superintendent of maintenance, for this department cares for roll neck bearings after they have been placed in operation. However, maintenance of roll neck bearings is not exclusively a function of the mechanical department, as it is affected by the engineering, operating, and executive departments as well.

H. D. ROBB

To demonstrate the necessity and value of all departments co-operating and giving thought to the maintenance of roll neck bearings, let us review the points which each department should consider.

To illustrate, assume that we are interested in the purchase of a wide strip mill. In the purchase of new equipment the steel company will discuss its planned rolling schedule with the mill builder, who in turn will co-operate with the bearing manufacturer in the selection of suitable bearings to meet this schedule.

The progressive anti-friction bearing manufacturer now has a sufficient background of experience to enable him to give you a general idea of the life which you may expect from bearings on roll necks under certain set conditions of speeds and loads.

As far as maintenance is concerned, with the bearings used on the gear drives, pinion stand, tables, reduction units, cranes and other auxiliary equipment necessary in a successful mill, practically no care is required other than to see that suitable lubrication with an approved lubricant is available at all times and that the seals are functioning properly.

With roll neck bearings, however, we have a different problem. The anti-friction bearing manufacturer could, under given conditions, build roll neck bearings which would give unlimited life. As compared with our present day practices this would mean enormously large bearings which in turn would mean extremely large rolls. This would of course involve a correspondingly large increase in capital investment.

The points which will now come up relative to the maintenance of roll neck bearings in this hypothetical mill will apply to a greater or less degree on any other mill application. We would suggest a bearing with, say, an outside diameter of 42" that should give an average bearing life of 10,000 hours with the back-up rolls approximately 49" in diameter. The management might not feel that 10,000 hours life was sufficient and prefer a longer life. The bearing manufacturer would probably then suggest a 47" diameter bearing, which in turn would necessitate a 54" back-up roll. This bearing may now give 15,000 hours average life, but there will be a corresponding increase in price of the bearings, the larger rolls, and the other equipment.

The management is primarily interested in the bearing cost per ton of steel rolled. This cost is determined by the life of the bearings based on the number of tons rolled before the bearings are worn out, plus repair and overhead charges. Assume now that these points have all been given due consideration and that the management has finally decided that bearings selected on the basis of 15,000 hours average life are most economical for their particular job.

The engineering and executive departments, as you will note, have now had a great deal to do with the ultimate maintenance of the roll neck bearings, for they have determined the time at which the superintendent of maintenance must be on the look-out for fatigue failures of the bearings.

However, this planned program may be entirely wrecked by an uneducated or reckless operating department, who in the hopes of getting increasd production, load the bearings beyond the capacity for which they were designed, with a corresponding decrease in the life of the bearings. There have been several instances, especially in the cold rolling of thin strip, where the roller, when new mills were installed, tightened the screws to such an extent that the ends of the rolls were embedded one into the other. As experience was gained in these new mills they found that it was possible to decrease the pressure 50% or more and get just as satisfactory a product.

Several companies have installed pressure recording instruments on their mills and adjust their rolls according to pressure rather than to a predetermined gauge or to give a definite reduction. They

have found that there is a definite relation between pressure and reduction, and by balancing the two they are able to control screw pressures and still get their desired reductions. Thus they get the desired results, plus a longer bearing life because of the decreased loads.

The load imposed on a bearing in relation to its capacity to withstand this load will affect maintenance to a considerable degree. For example, I recall one instance where a mill had operated successfully for several years with practically no bearing maintenance. With the increasing demand for thin gauge stainless steel and high silicon steel, this company found that to get the reductions desirable they had to practically double the screw pressures formerly used. Naturally, this large increase in pressures increased bearing maintenance, for when bearing loads are doubled, bearing life is decreased to about one tenth of that normally anticipated. Conversely, if bearing loads are cut in half, the life is increased approximately ten times.

Several of the newer mill installations have devices which register a warning when a bearing is in trouble. The majority of the older mills, however, do not have such devices. When a bearing is in trouble on a roll neck it usually gives an indication either by an increase in temperature or noise in the bearing chocks. Certain plants, when a bearing gives notice of trouble, notify the maintenance department. They in turn usually order the mill shut down and the bearing removed for examination.

In one plant that I know of, the superintendent is apparently interested in only one thing, production. In his case, even when the bearings give indications of trouble the mill continues to operate until the turn is finished or it is necessary to regrind the roll. In the case of the former plant, the bearing is removed when it first indicates trouble. They ordinarily find that one of the rolls has started to fatigue. It is a comparatively simple matter to take out this bearing roll and install a new one. In the case of the second plant, with a broken roll grinding through the races, by the end of the turn the bearing will probably be a complete wreck.

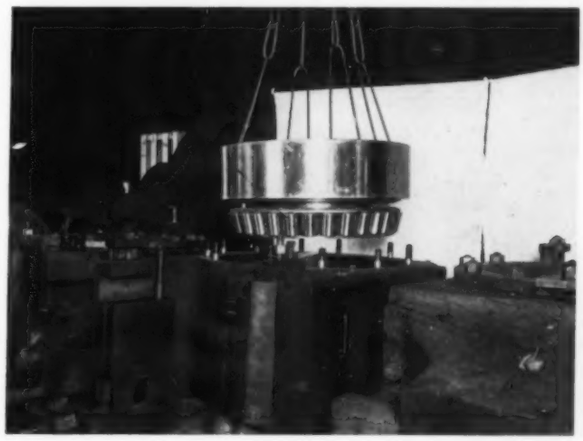
If low maintenance is required, it is therefore desirable that the maintenance department have sufficient control of this end of the operating department that they can issue instructions to have a damaged bearing removed from the roll neck before it is a complete wreck.

Bearings should be properly aligned in the mill if full life is to be secured, and care taken to see that the wedges are so assembled that the chocks on the floating side are free to find their own centers and are not restricted between the two housings. It is also essential that the rolls are not crossed, causing extreme thrust loads not anticipated in the design.

The average mill is heavily loaded and the rolls deflect under load. It is desirable that the bearings follow the deflection of the rolls and it is therefore suggested that the chocks be so built that they can follow the deflection of the rolls. Our experience has shown that the chocks should be built with a flat on the bottom chock which will give approximately 15,000 pounds per square inch and that the bottom of the chock be beveled off on a taper to a depth of about 1/16" at the end of the chock. Where clamps are used on the fixed chock it is recommended that these should also be beveled.

In the purchase of a new mill it is desirable to order spare bearings which can be mounted on spare rolls to facilitate a quick roll change. Some of these spare bearings will not be immediately placed in chocks, and the maintenance men must see that they are properly handled. By this, I mean that the bearings should be kept in a part of the mill which is clean and free from moisture. I know of one unfortunate condition which now exists in a plant where they do not have a suitable room to store and care for the roll neck bearings. The space allotted to them is in close proximity to the pickling tanks. Unfortunately, the fumes from these tanks have in some cases attacked the bearings, causing corrosion.

Even the slightest corrosion may be sufficient to cause spalling when the bearings are put in service under heavy loads, and further, there is the ever-present danger of inducing corrosion-fatigue when even a small amount of water gets into the lubricant. It has been demonstrated that failure of a metal part due to corrosion-fatigue may occur at a stress far below the normal fatigue limit, even though the actual amount of corrosion is unbelievably small.



In this illustration is shown Timken Bearings being assembled in chocks for 96" plate mill. Bearings 29" x 46½" x 29"

The importance of proper maintenance prior to use as well as when in actual service is therefore evident.

Anti-friction bearings are a precision product in spite of their size, and must be handled accordingly. The maintenance department must see that when bearings are mounted in the chocks and on the roll necks that they are not handled too roughly.

Roll neck bearings can be lubricated with either oil or grease, but experience has shown that with the exception of very high speed mills it is better to use grease, as it is easier to keep water and mill scale out of the bearing chocks. It is important to use the proper kind of grease, and upon request our chemist will be glad to furnish a list of approved lubricants for roll necks. With high unit pressures we have found it desirable to use an E P lubricant.

The Timken Roller Bearing Company was among the pioneers in working with the lubricating companies in the development of E P lubricants. Short-

_____ BEARING NO. _____

MAKER _____ REC. _____ DATE RECEIVED _____

REMARKS : _____

Roll No.	Case No.	Thrust or Float	In Mill No.	Top or Bot.	Service Date		Tonnage	Total Tonnage	REMARKS
					Put In	Taken Out			

ly after the installation of one of the first 2-row assembly bearings on a back-up roll considerable trouble occurred. A large amount of time and money was spent in trying to find the source of the difficulty, but it was finally traced to the lubricant. This was changed to an E P type, and we are glad to report that many of these original bearings have now rolled approximately 1,000,000 tons of steel.

Spare bearings should be available to permit periodic inspection of the bearings in service. Such inspection accomplishes a fourfold purpose:

1. The old grease which has been in the chocks, and which may be contaminated with water or dirt, is removed.

2. As bearings reach their fatigue life it is found that a fatigue failure, which can be detected by spalled conditions of the component parts of the bearing, usually does not occur on all parts at the same time. It may be found on inspection that one or more rolls have reached the limit of their life. These rolls can be removed at this time and new rolls installed, thus prolonging the total life of the bearings.

Spalled sections on either the inner or outer race may be discovered. If these are of a limited extent, the bearing life may be prolonged by touching up the spalled areas by means of a dental grinding tool. If the spalled section is extensive, it may be found desirable to return the race to the bearing manufacturer's factory where it can be reground.

The outer portion of the bearing, or cup, does not rotate, and consequently there is a concentrated load on a comparatively small section of this outer race. It is therefore desirable to see that the cup is rotated 90° in the housing when inspections are made.

3. As all rotating parts in a machine will eventually wear, in the re-assembly of bearings in the chocks the clearance, or adjustment of the bearings, should be checked. If wear has occurred, a shim should be removed or a spacer ring reground in order to bring the rolls into closer relationship with the outer and inner races. Best results will be secured if a clearance of about .0005 to .001" between the rolls and the races is maintained. I might add that adjustability is one of the special advantages in the use of tapered roller bearings for roll neck applications.

4. Another advantage in periodic inspection, especially on high speed strip mills with loose fitted bearings, is that scoring of the roll neck will be minimized. I recall one instance on a back-up roll of a 4-high hot strip mill where when the bearings were left on the neck for a period of three months there was practically no scoring of the roll neck. When they were left on for a period of six months there was an average wear of about .006" and when the bearings were left on the neck for nine months the wear had increased to about .015".

Recent experience has shown that bearings work harden in service and we have found that by treating these bearings in drawing tanks that work strains are relieved. We merely mention this fact in passing as this point will be thoroughly covered in Mr. Keener's paper, which will be given later.

Inspection will be easier if the bearings are placed on a shallow pan where most of the grease can be removed as soon as they are taken out of the chocks. They can then be placed in a tank filled with a solution of washing compound such as trisodium phosphate, using about three or four ounces of this material to a gallon of water. While the bearing is immersed in this solution it should be agitated by live steam. This treatment will clean the bearing thoroughly and a thorough inspection can then be made.

In closing, we strongly urge the keeping of accurate records on bearing tonnage and suggest the above form, illustrated in this paper, which may be made out on an 8½x11" sheet as one company now does.

At the top of this chart, reading lengthwise, they show the bearing number; on the second line they list the maker, requisition number and date received; and on the third line, remarks. Under this they have divided the paper as follows: First column, roll num-

ber; Second column, chock number; Third column, thrust or float; Fourth column, in mill number; Fifth column, top or bottom position; Sixth column, service date (under which they have a sub-column "put in mill" and another sub-column "taken out of mill"); Seventh column, tonnage; and Eighth column, total tonnage; after which is a large column for remarks.

These charts should be watched carefully and if you are not obtaining the life you expect from your anti-friction bearings it is advisable to get in touch with the bearing manufacturer as he may be able to assist you in finding the reason why you are not obtaining the tonnage you should expect.

FIELD DRAWING OF ROLL NECK BEARINGS

By S. F. KEENER,
Salem Engineering Company, Salem, Ohio

Paper presented before the A. I. & S. E. E. Spring Engineering Conference held in Youngstown, Ohio, April 24 and 25, 1935.

S. F. KEENER

The brief paper which I am about to present has been prepared as a supplement to Mr. Robb's paper on the maintenance of roll neck bearings. The purpose of the paper is to discuss some of the principal features of the oil draw equipment required for field drawing of roller bearings as recommended by Timken Roller Bearing Company.

Th duty on the roll neck bearings of modern mills has increased to the point where the maintenance of these bearings is a matter of serious concern. This is particularly true in view of the fact that failure of mill bearings will cause a shut down and loss of production from the mill, which is an extremely expensive catastrophe in the case of a modern continuous mill with its high rate of production. Maintenance is, no doubt, having an increasing effect on the consumption of red ink in the auditing departments.

It has been my privilege to follow the developments in the heat treatment of roll neck bearings almost from the beginning of the production of such bearings by the Timken Company. The development of the special equipment and methods for the hardening, quenching and drawing of this product has been an interesting story. Briefly, it involves the exact treatment of a large mass, which is always a difficult problem.

The special conditions for which the drawing furnace under consideration must be designed, can be briefly summarized as follows:

(1)—Exact Temperature Uniformity

For uniform drawing and for proper metallurgical treatment of a steel of relatively high carbon content, a maximum temperature variation on all parts of the bearing of 10° F. plus or minus is desirable, and such a variation is possible only with the best in heating equipment.

(2)—Low Temperature of Operation

The temperature recommended as the result of the Timken research for field drawing is between 325° and 350° F. At these temperatures the transfer of heat is more than half by convection, which increases the difficulty of obtaining the uniformity of temperature required.

(3)—Mass to be Heated

Most roll neck bearings are from 18″ to 53″ in diameter and the thickness of section is up to 6″. Such dimensions mean that a large area must be held at uniform temperature for a long period of time, while the interior of the mass slowly approaches the outside temperature. The weight of such pieces is also an important consideration in the selection of the type of equipment to be used.

(4)—Variation in Size of Product

The bearings on the work rolls and on the back-up rolls of the usual mill vary widely in size and a considerable study is necessary in fixing the size of the furnace and the disposition of the bearings therein, while heating.

(5)—Intermittent Operation

For best results, it is recommended that bearings be treated every three to six months and between treatments, the equipment unless other uses can be found for it, must lie idle. This condition

requires a furnace of the lowest possible first cost that is consistent with the exact operating requirements. The idea that the field drawing equipment might be utilized for strain relief of mill rolls has been repeatedly advanced. That severe strains do exist is apparent to any one who has observed the explosion of a roll lying idle on the floor. It is true that new rolls which have not been subjected to working stresses will also explode, and my reaction to this would be that a treatment for relief of strains of new rolls would be indicated. If the drawing equipment could be utilized beneficially for strain relief of rolls, the question of idle periods would cease to exist.

Selection of Furnace

The reasoning which has resulted in the selection of an electrically heated oil bath for these requirements is somewhat as follows—

The choice of heating methods at this temperature lies between a liquid medium and open heating. For the required uniformity, circulation is essential in either case. In the liquid medium this may be accomplished by a simple propellor or pump, while for open heating, circulating fans would be required in an electric furnace, or an external fuel fired combustion chamber with a hot gas fan might be employed. In the first case the uniform circulation of air is more difficult and the rate of heat transfer is not as great as with the liquid medium. In the second case, the first cost and floor space requirements are in favor of the liquid bath. Finally, the use of a pot with top opening is indicated by the necessity for handling heavy pieces.

This illustration shows the field drawing equipment used by The Timken Roller Bearing Company.

Having selected the oil bath with a circulating propellor, it becomes evident from an examination of the size of the bath, that external heating of the bath will involve considerable difficulties with pot construction and maintenance. Further, an externally fired pot will shorten the useful period of the oil in the bath, due to the fact that it is apt to come in contact with portions of the tank which have been heated to temperatures sufficiently high to break down the oil. Immersion heating and insulation of the pot itself is the obvious solution, from a consideration of first cost and economy of operation.

Immersion heating may be accomplished by electric elements of simple construction, or by gas fired metal tubes with equally satisfactory results, but the greater simplicity of the electric elements will in most cases more than offset any difference in economy as compared with the use of gas.

The drawing pit which I prefer, consists of an insulated metal container with the cover arranged for easy handling. Electric heating elements of proper area surround the inner wall, and by the use of a propellor and proper baffles, a uniform circulattion of the oil is maintained in all parts of the bath. The heating material rests on a heavy supporting rack in the bottom of the furnace, and the furnace is located in a pit, with the top projecting above the floor to a suitable height for loading.

Operating Economy

As has been outlined above, the first cost of the equipment is of greater importance than the cost of operation, but a few figures on this economy will be of interest.

The energy consumption of the electric oil draw varies of course with the production. Operating records of one of these furnaces in operation for several years show an average production of 1000 pounds of bearings treated per hour of operation, with a maximum production of 3000 pounds per hour. In the first case, the energy consumption is 54 K.W.H. per ton, and at the maximum rate, 22 K.W.H. per ton. The connected load of the furnace is 25 K V A.

A summary of the approximate cost of heating bearings by the several possible methods is shown below. In preparing these figures we have used the average heating rate of 1000 pounds per hour, and have assumed a cost of 1c per K.W.H. for electric energy, and 40c per thousand cubic feet for natural gas:

Open heating, natural gas	20c per ton
Oil draw, gas immersion burners	14c " "
Electric oil draw	54c " "

In conclusion, it is claimed that the electrically heated oil draw furnace as described, when properly designed, offers the best method for carrying out the metallurgical process of field drawing of roll neck bearings developed by the Timken Company.

I believe this to be a worthwhile contribution and that adoption of this practice will prolong somewhat the usefulness and life of roll neck bearings, and even though anti-friction bearings for roll necks are rendering a service that is satisfactory from a cost standpoint, any treatment which will prolong that life, is of special interest from a maintenance standpoint.

ROLL NECK BEARINGS

By G. PALMGREN,
Chief Engineer, SKF Industries, Inc.,
Philadelphia, Pa.

Paper presented before the A. I. & S. E. E. Spring Engineering Conference held in Youngstown, Ohio, April 24 and 25, 1935. Also presented before the Pittsburgh District Section of the A. I. & S. E. E. March 16, 1935.

G. PALMGREN

Up to the present time we have installed roller bearings on roll necks of more than 1200 stands, which include all types of cold and hot rolling mills ranging in size up to 50" backup roll diameter and speeds up to 1550 RPM, corresponding to a delivery speed of 4550 FPM, in continuous rod mills. It may, therefore, be of some interest to discuss the development of the designs used and the experience obtained.

FIG. 1—Two spherical roller bearings for 28" roll neck. The inner race can be turned and the bearing easily cleaned and inspected.

In practically all the cases the SKF spherical roller bearing has been used. This bearing is a double row self-aligning type. The outer race is made with a spherical raceway, with the center point at the center of the bearing and can, therefore, be turned in any direction as may be seen on Figure 1. Owing to the shape and position of the rollers, a component force is produced which holds the rollers permanently against the middle flange of the inner race. The end of the rollers and the guiding surface of the middle flange are both ground spherical with the same radius, so that full surface contact between the roller ends and the guiding flange will be effected. This design, which is an SKF patent, will effect an absolutely positive guiding of the rollers with very low bearing friction and the absence of wear or smearing of the roller ends. The bearing, which is a self-contained unit, can also carry a considerable degree of thrust load. For instance, the ordinary medium standard series has a thrust capacity of 50% of the radial capacity. The design is compact so that the sizes and number of rollers will give the highest possible capacity within a given space. The self-aligning feature is naturally a most important one as this will always effect a proper distribution of the load on the rollers, which means effectively preventing unexpected overload or peening of any part of the bearing.

In some cases, as for instance, in hot rolling mills with grooved rolls, the outer race is made in two pieces so that the two outer race sections can be tightened against each other and all internal clearance in the bearing eliminated.

Carrying Capacity

It has been proven that the carrying capacity of a bearing cannot be determined by means of theoretical calculations only, owing to the complicated nature of the conditions set up by the bearing elements as a result of the elastic deformation that occurs when two bodies with curved surfaces come in contact with each other. It is, therefore, necessary to base calculations of bearing capacities principally on laboratory tests and practical experience. We have not less than five different laboratories in America, Sweden, Germany, France, and England, where bearings of various types and sizes are constantly tested under various loads and speeds. Over a long period of years, thousands and thousands of bearings have been tested, so that in this way we have probably obtained a better knowledge of the relationship between bearing design, bearing load, and bearing life than anyone else.

Hot Rolling Mills

It is not enough to know all about the bearings; it is also necessary to know the actual loads in the mills. Before any of the early applications were designed and made, loads and their variations were measured in each case. By so doing we could figure the expected life for the bearings and thus insure that there was no hazard involved. From the begin-

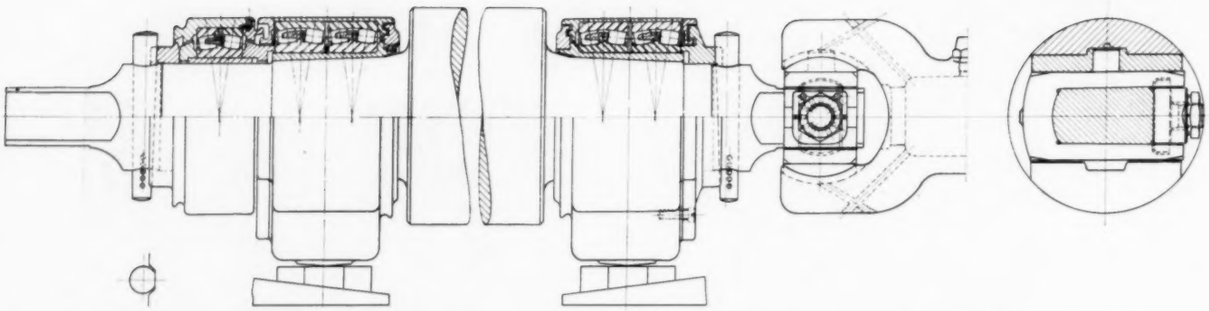


FIG. 2—Bearing mounting for grooved rolls in hot rolling mills. The bearings and the tapered sleeves are tightened on the tapered necks by wedges driven into holes through the necks.

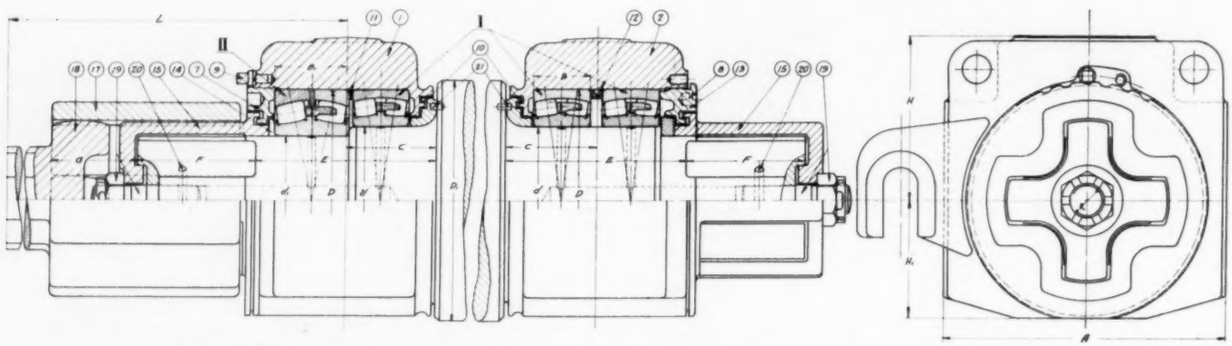
ning the results also were the very best as far as fatigue failure is concerned.

Later on in 1926 Mr. Ekelund developed formulas for calculating loads in hot rolling mills. These formulas were published in detail in the magazine "Steel," August and October of 1933. The formula takes into consideration all factors, such as reduction of material rolled, roll diameter, temperature, speed, analysis of material rolled, friction between roll and material, etc.

We have checked these formulas with measurements made in wire mills, blooming mills, strip mills, etc., and found that the estimated values are always close enough to the measured ones. The difference will seldom be more than $\mp$ 20%. The only exception is that the formula gives too high loads in cases where the speed is higher than 2000 FPM., as for instance in continuous rod and strip mills. We now use these formulas regularly with marked success.

Development of Designs for Hot Rolling Mill Necks

The first bearings of our type for roll necks were applied by Eisenwerk Witkowitz in Czechoslovakia in three finishing stands in an 11" rod mill as early as 1921. One spherical roller bearing was used on each neck, mounted with a loose fit, to facilitate roll changes. The thrust load was taken by thrust ball



Size No	Roller Bearing I				Roller Bearing II				Housing					Rollneck								D, Min	
	No.	d	D	B	No.	d_1	D_1	B_1	D	A	H	H_1	d	d_1	C	E	F	G	L	K	2-High	3-High
2	1.28902	4.7244	7.0866	1.811	1.12568	4.3307	7.0866	2.205	7.0866 +.0000 −.0008	4⅜	5⅜	5¾	4.7211 +.0000 −.0010	6.9278 +.0000 −.0010	2⅞	5⅜	4	3	15¾	1	7⅞	8
3	03	5.1181	7.4778	1.969	03	4.5216	7.4778	2.520	7.4766 "	9¾	8⅜	4	5.1148 "	6.5299 "	3	6⅜	4½	3½	16⅞	1⅛	8¼	8⅜
4	04	5.5118	8.2677	2.087	04	4.7246	8.2677	2.835	8.2471 "	10⅛	6	4⅝	5.5085 "	6.7211 +.0000 −.0010	3⅛	6⅞	4¾	3⅝	17	1⅛	8⅝	9⅜
5	05	5.9055	8.8583	2.205	05	5.1181	8.8583	2.992	8.8579 "	11⅜	6½	4⅝	5.9052 "	5.1148 "	3⅜	7	4⅞	3⅝	17⅞	1⅛	9⅜	9⅞
6	06	6.2992	9.4488	2.362	06	5.5118	9.4488	3.150	9.4488 "	12	7	4⅝	6.2989 "	8.5085 "	3½	7⅞	4⅞	3¾	19⅛	1⅜	9⅝	10⅜
7	07	6.6929	9.8425	2.362	07	5.9055	9.8425	3.150	9.8819 +.0000 −.0080	12⅜	7⅜	5⅛	6.6896 "	5.9052 "	4	7⅞	5	4	19¾	1¼	10⅝	11¼
8	08	7.0866	10.4331	2.520	08	6.2992	10.4331	3.307	10.4325 "	13⅛	7¾	5⅜	7.0857 +.0000 −.0010	6.2959 "	4⅜	8⅜	5⅜	4⅜	20⅜	1⅜	10⅞	11⅞
9	09	7.4803	11.0236	2.638	09	6.6929	11.0236	3.465	11.0230 "	13⅞	7⅞	5⅝	7.4764 "	6.6896 "	4⅝	8⅞	5⅞	4⅝	21⅛	1⅜	11⅜	12⅜
10	10	7.8740	11.6142	2.795	10	7.0866	11.6142	3.623	11.6136 "	14⅝	8⅜	6	7.8701 "	7.0857 +.0000 −.0010	4⅞	9⅛	5⅝	4⅞	22⅛	1½	12⅛	12⅞
11	11	8.2677	12.2047	2.953	11	7.3936	12.2047	3.858	12.2041 "	15⅜	8⅞	6⅝	8.2638 "	7.7796 "	4⅝	9½	5⅞	5	23⅜	1½	12⅞	13½
12	12	8.6614	12.8984	2.992	12	7.4803	12.5984	4.095	12.5977 +.0031 −.0000	15⅜	9⅛	6½	8.6575 "	7.4764 "	4¾	9⅞	6	5⅛	24⅜	1⅝	13⅜	14
13	13	9.0551	13.1890	3.150	13	7.8740	13.1890	4.252	13.1883 "	16⅝	9⅞	6¾	9.0512 "	7.8701 "	5	10⅛	6⅜	5⅜	25½	1⅝	13⅝	14⅝
14	14	9.4488	13.7796	3.268	14	8.1677	13.7795	4.409	13.7788 "	17⅜	9⅞	7⅛	9.4449 "	8.2638 "	5⅛	10⅜	6⅝	5½	26⅛	1⅝	14⅜	15⅜
15	15	9.8425	14.3701	3.425	15	8.6614	14.3701	4.567	14.3694 "	18⅛	10¼	7½	9.8382 +.0000 −.0031	8.6575 "	5⅜	11⅜	6⅝	5⅝	27¼	1⅝	14⅞	16⅛
16	16	10.2362	14.9606	3.543	16	9.0551	14.9606	4.724	14.9599 "	18⅞	10⅝	7⅝	10.2319 "	9.0512 "	5⅝	11½	6⅞	6	28⅛	1⅝	15⅜	16⅝
17	17	10.8299	15.5512	3.701	17	9.4488	15.5512	4.882	15.5505 "	19⅜	11¼	8	10.8256 "	9.4449 "	5⅝	11⅞	7	6⅜	29⅛	1⅝	16⅛	17⅜
18	18	11.0236	16.1417	3.858	18	9.8425	16.1417	5.039	16.1409 +.0035 −.0000	20⅛	11⅝	8⅜	11.0193 "	9.8382 +.0000 −.0031	6	12⅛	7⅛	6⅜	30⅛	1⅝	16⅞	18
19	19	11.8173	16.7323	4.016	19	10.0394	16.7323	5.354	16.7315 "	20⅞	12	8⅝	11.8130 "	10.0351 "	6⅛	12⅝	7⅜	6⅞	31	1⅝	17⅜	18⅜
20	20	11.8110	17.3228	4.134	20	10.2362	17.3228	5.669	17.3220 "	21⅜	12⅜	8⅞	11.8067 "	10.2319 "	6⅜	13⅛	7½	6⅞	31⅞	2	17⅞	19⅜
21	21	12.2047	17.9134	4.291	21	10.6299	17.9134	5.827	17.9126 "	22⅛	12⅝	9¼	12.2004 "	10.6256 "	6½	13⅝	7⅝	6⅞	32⅜	2	18⅜	20
22	22	12.5984	18.5039	4.449	22	11.0236	18.5039	5.984	18.503 "	23⅛	13⅛	9⅜	12.5935 +.0000 −.0035	11.0193 "	6¾	14⅛	7⅞	7⅛	33⅝	2	19⅜	20⅞
23	23	12.9921	19.0945	4.567	23	11.4173	19.0945	6.142	19.0937 "	24	13⅝	9⅝	12.9872 "	11.4130 "	7	14⅝	8⅛	7⅜	34⅝	2¼	19⅞	21⅜
24	24	13.3858	19.6850	4.724	24	11.8110	19.6850	6.299	19.684 +.0035 −.0000	24⅞	14⅛	10⅜	13.3809 "	11.8067 "	7⅛	15	8⅜	7⅞	35⅞	2¼	20⅛	22¼

FIG. 3—Loose fit mounting for grooved rolls in hot rolling mills. Oil is introduced in holes drilled in the roll necks and constantly transmitted to the neck surface, protecting the necks from wear or smearing.

bearings. The power saving was over 40% and it was possible to roll much more accurately than before. Witkowitz was, therefore, encouraged to go ahead and build more mills equipped with this type roller bearings.

The next mill built by Witkowitz with our bearings was a continuous 11" rod mill, where the material was roiled in two strands in the first four stands and three strands in the last stands. Also, here one spherical roller bearing was used per neck, mounted with a loose fit.

At about the same time Witkowitz also built some other mills of about the same design. In some cases with thrust bearings and in other cases without. As long as the speed was low the method of applying the bearings with a loose fit did not cause trouble, but in cases where the speed was higher, as for instance in a finishing wire mill, the bearing bores and the necks became badly worn. This was certainly a very valuable experience and influenced our later development in this field.

All the applications made by Witkowitz showed quite definitely that the roller bearings considerably improved the performance of the hot rolling mills;

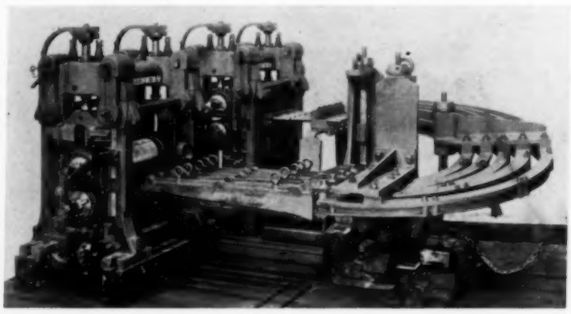


FIG. 4—Stands for 11" Garret mill where six to seven strands are rolled at the same time.

and consequently we started a more thorough study of this problem in 1922. We have our own steel mill in Sweden where excellent opportunities for trying roller bearings in various hot rolling mills existed. At the time when we started this work in our own mill, there was little opportunity for estimating the neck loads in hot rolling mills with sufficient accuracy; and we, therefore, started with a complete study of the conditions in a wire rolling mill, consisting of two three-high 17" roughing stands and eight 10" finishing stands. We measured the loads and their variation on all the necks and prepared diagrams showing in detail the loading conditions in the finishing mill when rolling wire.

After having made all these complete investigations and figured the expected life of the bearings, we applied the first roller bearings in one stand in the finishing mill in 1922 and in a second stand in 1923. In the early part of 1925 the entire mill was in operation on roller bearings, which were not only applied on the roll necks but also in the pinion stands and on the flywheel. The mills have since then been in continuous operation and the majority of the original bearings are still in use.

The development work continued in our steel plant; and during the years 1925 and 1926, we changed over one 10" rod mill, one 14" bar and strip

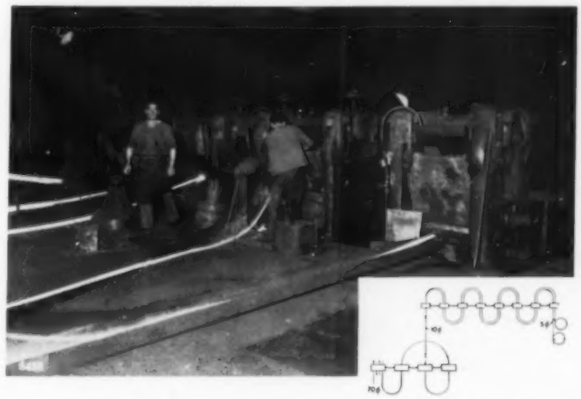


FIG. 5—Rod mill with one 14" roughing and one 10" finishing train.

mill and a finishing stand in a 25" bar mill. In all these cases we used different designs in order to prove in actual operation which one would be the most suitable. Interesting though it would be, it is unnecessary to go into all the steps of development. Let it suffice to mention that we based the designs upon mounting the bearings with a tight fit on tapered necks, in all cases, in order to overcome the trouble we had in some of the first mills with the loose fit mounting.

Designs for Hot Rolling Mills

In 1927 we had accumulated so much experience from different designs and various types of mills that we were completely prepared to go ahead and introduce our bearings to the market. The design we used at that time is illustrated in Figure 2, and has since been used in hundreds of stands most successfully. Two spherical roller bearings on each neck take the radial load and on one of the necks an additional bearing in a separate housing takes

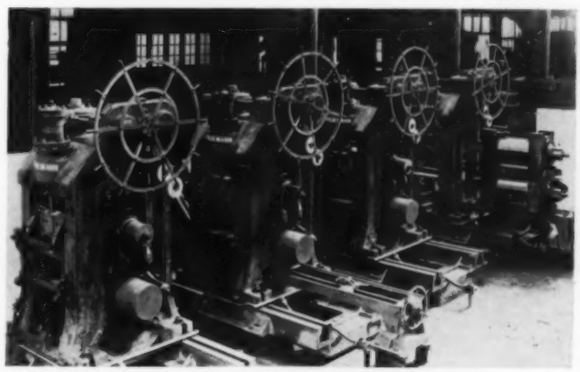


FIG. 6—Continuous three-high hot strip mill.

the thrust. The two bearings for radial load are mounted on a sleeve with a tapered bore, which is pressed on the tapered neck by a wedge driven

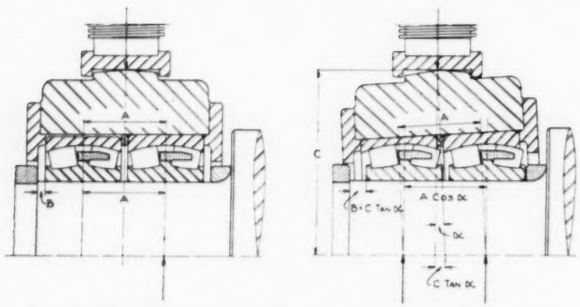


FIG. 7—Exaggerated illustration of how the load is always equally distributed over four rows of rollers in the self-aligning design independent to variation in bearing sizes or neck deflections.

through the neck. On the loaded side the radial bearing housings are provided with inclined surfaces so that the load is carried only in the middle of the housing and permitting the housing to align itself with the roll neck. Even distribution of the load on both bearings is thus assured. The bearing for thrust load is mounted in a separate housing which can align itself in all directions around the center point of the self-aligning bearing, which means that the thrust load will always be equally distributed over all the rollers. The outer race of this bearing is split to permit the two-ring sections to be tightened against each other by means of a threaded end cover so that all internal looseness in the bearing is taken out, thus insuring positive lateral guidance of the roll. The housing for thrust load is applied to the stand so that it is possible to adjust the roll in either direction by turning only one adjusting screw. By doing this the thrust bearing will tilt around the center point of the bearing to some extent, which will not affect the correct distribution of the load in the bearing.

In two-high and three-high mills where only flats are rolled on plain rolls, the extra bearing for thrust and also the arrangement for axial adjustment have been dropped.

Couplings

In Figure 2 a Universal type of coupling is shown. This coupling was designed and used in a number of cases in order to overcome some trouble we had during the first years. It is well known that in rolling mills shocks occur in the couplings, especially in heavy mills, causing the front end of the rolled material to be bent. With plain bearings this is overcome by tightening the plain bearings so that a certain braking action is introduced. The braking effect thus produced eliminates play in the coupling. With roller bearings this braking cannot be produced. It is, therefore, necessary either to provide brake pullleys on the undriven ends of the rolls in the last stand in order to eliminate back-lash in the couplings or to use some type of coupling that can transmit torque at an angle without having play. We preferred the latter alternative as the most foolproof and have made the Universal coupling so that it can transmit a considerable amount of torque. It is very simple to mount and dismount. We found that this type of coupling worked successfully and was advisable to use in mills with over 12" rolls. The coupling takes very little space in an axial direction, transmits power without play in the direction of rotation, even when the axes of the rotating parts are very much out of parallel. In addition, the couplings run very smoothly and do not cause axial shock loads with the result that it is easier to keep very close tolerances in mills with grooved rolls than with the ordinary muff coupling. An objection is that the coupling must be frequently lubricated in order to get a long life. The cylindrical bronze discs when worn slightly can easily be changed.

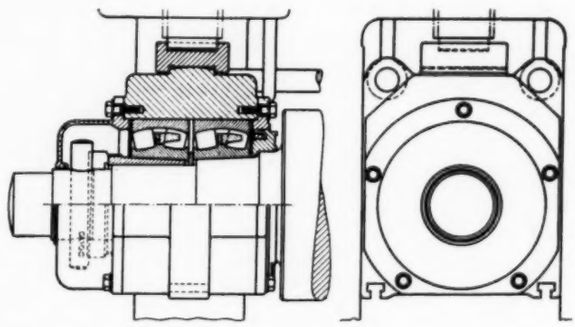


FIG. 8—Bearing application for back-up rolls in cold rolling mills. The two heavy bearings are mounted tight on the neck.

In small high speed rolling mills the couplings of an ordinary type can very well be used; but in that case, it is most advisable to make them in a different way from the ordinary so that the play in the direction of rotation will be reduced.

Changing Rolls

When changing rolls the top of the stands are loosened and the rolls with roller bearings lifted out. It is a simple operation to remove the bearings from the necks. A wedge tool driven between the bearings and the end of the roll by a couple of blows on this tool, will loosen the bearings from the neck and they may then be handled as completely self-contained units.

In mills equipped with our roller bearings and mounted according to our design, roll changes do not take any more time than when plain bearings were used. For instance, in an 11" rod mill, the rolls are changed in from twenty to twenty-five minutes provided a spare set of bearings had been mounted on the new rolls before the mill was shut down. To change the bearings from one set of rolls to another, it will take an additional ten to fifteen minutes. For a mill with five to seven stands, two sets of spare bearings have been found to be sufficient, so that when rolls are changed in the two last stands the spare bearings can be mounted on the new rolls before the roll change is begun. More than two sets of spares have not been found necessary.

Loose Fit Mountings

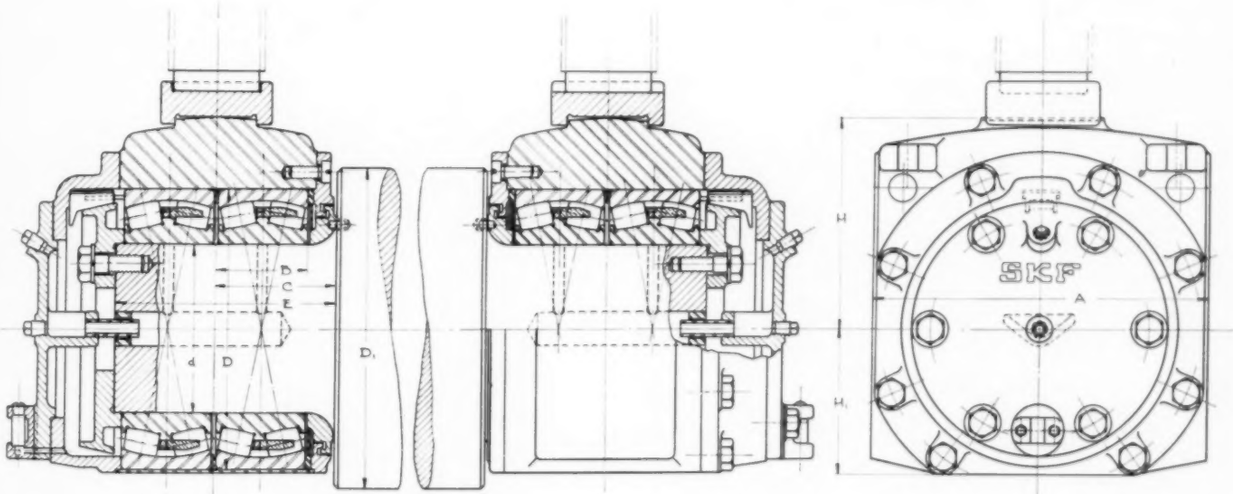
In all the cases described so far, the tight fit principle has been used and from a purely technical standpoint that type of mounting has proven most successful. There has, however, been some resistance from a number of prospective customers against that type of mounting. It has also been found hard to

use the tapered neck design in cases where existing rolls should be used for roller bearings and the lengths of the existing necks were not great enough to allow the use of threaded nuts, wedges or similar arrangement to tighten the taper sleeve on the neck. We have, therefore, considerably improved the loose fit mounting and made it possible to use this principle at all rod mill speeds.

In 1929 we started to use the design shown in Figure 3. Here the two bearings are applied with a loose fit directly on a cylindrical neck. One of the two bearings on one neck is made heavier so that that bearing can carry not only one-half of the radial neck load but also the total thrust load. This bearing is made with a split outer race for the removal of internal clearance. The main reason that this bearing is made heavier is that we can then, without increasing the bending stresses on the neck, get a bearing that can carry the thrust load with a minimum of yield. The locating bearing is tightened to the neck by a crown shaped sleeve put over the end of the roll neck and tightened by a screw at the end of the roll. This crowned sleeve is so made that a muff will contact the neck surface directly and the sleeve need take only the thrust load on the bearing and no torque.

In the first applications already referred to in which we used a loose fit mounting, we did not have any arrangement for lubricating the surface between the neck and the bearing inner races. We have, however, found the lubrication of these surfaces most important and we, therefore, now drill the center of each neck to form a reservoir with small radial holes leading from the center to the neck surface. These reservoirs are filled with a suitable oil every time the bearings are changed, the oil continuously lubricating the neck surfaces during the operation. The oil introduced in this way is sufficient to prevent wear and scoring of the neck. If this system of neck lubrication is not used, the lubricant will, above some certain speed, no longer tend to work its way in between the neck and the inner race, with the result that difficulties will appear if that speed is exceeded. This was the case in some of the first applications made with the loose fit mounting. If the oil, however, is fed to the middle of the bearing seat it will always lubricate the necks at high speeds, so that with this arrangement the loose fit mounting can be used at high speeds also. This has been proven in a number of installations.

Also in this case the bearings can be tightened axially to the neck by means of wedges through the neck. If the rolls must be used a long time without being changed, it may be advisable to arrange so that more oil can be supplied to the center hole in



TAB. No	ROLLER BEARING No	d	D	B	HOUSING D	A	H	H_1	ROLLNECK d	C	E	ROLL D, Min
2	1-112402	4 3307	7 0866	2 205	7 0860 + .0015 .0000	8 3/8	5 5/8	5 11/16	4 3279 + .0000 -.0014	5 1/4	5 3/4	7 7/16
3	03	4 5276	7 6772	2 520	7 6760 -	9 1/2	6	6	4 5048	5 5/8	6 1/2	8 1/16
4	04	4 7244	8 2677	2 835	8 2671 -	9 3/8	6 3/8	6 3/8	4 7211 + .0000 -.0016	6	7 3/8	8 7/16
5	05	5 1181	8 8583	3 032	8 8577 -	10 1/2	6 3/4	6 7/8	5 1148	6 1/4	7 3/4	9 3/16
6	06	5 3116	9 4488	3 150	9 4482 -	11 1/8	7 1/8	7 1/8	5 3085	6 3/4	8 1/8	9 7/16
7	07	5 3055	9 8425	3 150	9 8419 + .0006 .0000	11 1/8	7 1/2	7 1/8	5 3022	6 3/4	8 1/8	10 1/16
8	08	6 2992	10 4331	3 307	10 4325 -	12 1/4	7 7/8	7 7/8	6 2953	6 7/8	8 1/2	10 7/16
9	09	6 6929	11 0236	3 465	11 0230 -	12	8 1/2	8 1/16	6 6856	6 3/4	8 3/4	11 1/16
10	10	7 0866	11 8142	3 622	11 8136 -	12 5/8	8 1/8	8	7 0827 + .0002 .0000	8	9 1/8	12 1/16
11	11	7 2835	12 2047	3 858	12 2041 -	14 3/8	9 1/4	8 5/8	7 2799	8 1/8	9 3/4	12 7/16
12	12	7 4803	12 5984	4 055	12 5977 + .0003 .0000	14 7/8	9 3/8	8 1/2	7 4764	8 7/8	10 1/4	13 1/16
13	13	7 6740	13 1890	4 252	13 1883 -	15 3/8	10	8 15/16	7 6701	8 3/4	10 1/2	13 5/8
14	14	8 2677	13 7796	4 409	13 7788 -	16 1/4	10 1/2	7 1/8	8 2638	6	10 7/8	14 5/16
15	15	8 6614	14 3701	4 570	14 3694 -	17	11	7 5/8	8 6575	6 1/8	11 1/8	14 15/16
16	16	9 0551	14 9606	4 724	14 9599 -	17 5/8	11 1/2	7 11/16	9 0512	6 3/8	11 3/8	15 5/16
17	17	9 4488	15 5512	4 882	15 5505 -	18 3/8	12	8	9 4449	6 1/2	12 1/8	16 1/16
18	18	9 8425	16 1417	5 035	16 4409 + .0012 .0000	19	12 1/4	8 5/16	9 8382 + .0007 -.0013	6 3/4	12 1/2	16 7/16
19	19	10 0394	16 7323	5 354	16 7316 -	19 3/4	12 7/8	8 5/8	10 0351 -	7 1/8	13	17 1/16
20	20	10 2362	17 3228	5 669	17 3220 -	20 3/4	13	8 15/16	10 2319 -	7 1/2	13 3/8	17 7/16
21	21	10 6299	17 9134	5 827	17 9126 -	21 1/8	13 5/8	9 1/8	10 6256 -	7 3/4	14 1/4	18 5/16
22	22	11 0236	18 5039	5 984	18 5031 -	21 3/4	14	9 5/16	11 0193 -	7 7/8	14 3/8	19 1/4
23	23	11 4173	19 0945	6 142	19 0937 -	22 1/2	14 3/8	9 7/8	11 4130 -	8 1/8	14 7/8	19 1/16
24	24	11 8110	19 6850	6 299	19 6841 + .0012 .0000	23	15	10 5/16	11 8067 -	8 3/8	15 1/4	20 1/16

TAB. No	ROLLER BEARING No	d	D	B	HOUSING D	A	H	H_1	ROLLNECK d	C	E	ROLL D, Min
26	1-112426	12 5984	20 8661	6 614	20 8661 + .0016 .0000	24 1/2	15 3/4	10 7/8	12 5933 + .0000 -.0016	8 3/4	15 1/4	21 11/16
28	28	12 9921	22 0472	7 244	22 0469 -	25 3/8	16 3/8	11 3/8	12 9875 -	9 1/2	17 3/8	22 3/4
30	30	13 7795	23 2283	7 559	23 2276 -	27 1/4	17 3/4	12 1/16	13 7746 -	9 3/8	18 1/8	24 1/16
31	31	14 2500	24 4094	7 874	24 4083 -	28 3/8	18 1/2	12 3/8	14 2420 -	10 1/4	19	25 3/16
32	32	15 3543	25 5905	8 189	25 5894 + .0020 .0000	30	19 1/2	13 3/16	15 3484 -	10 3/8	19 3/4	26 1/16
33	33	15 7480	26 3779	8 504	26 3769 -	30 3/8	20	13 5/8	15 7417 -	11 1/8	20 1/2	27 3/16
34	34	16 5354	27 5590	8 819	27 5580 -	32 3/8	21	14 3/16	16 5301 -	11 1/2	21 1/8	28 1/16
35	35	17 3228	28 7401	9 134	28 7391 -	33 1/2	21 3/4	14 7/16	17 3175 -	11 7/8	21 7/8	29 1/16
36	36	18 1102	29 9212	9 449	29 9202 -	35	22 3/4	15 1/8	18 1049 -	12 1/8	22 1/2	30 1/16
38	38	19 6850	32 2834	10 079	32 2823 + .0024 .0000	38	24	16 3/8	19 6793 -	13	24 1/2	33 1/16
40	40	20 8661	34 6456	11 024	34 6445 -	41	25 1/2	17 3/8	20 8604 -	14 1/4	26 1/2	36 1/16
42	42	22 0472	37 0078	11 969	37 0067 -	43 1/2	27	18 3/8	22 0415 -	15 3/8	28 3/8	37 15/16
44	44	23 2220	39 3700	12 598	39 3689 -	46 1/2	28 3/4	20 1/8	23 2160 + .0000 -.0020	16 1/2	30	40 5/16
46	46	24 8031	41 7322	13 228	41 7311 -	49	31	21 3/8	24 7971 -	17	31 1/2	42 5/16
48	48	25 9842	44 0944	14 488	44 0933 -	52	33	22 1/2	25 9782 -	18 1/8	34 3/4	46 1/16

FIG. 9—Loose fit mounting for back-up rolls in cold rolling mills. A device, which conducts the oil from the bottom of the bearing housing to the hole in the roll neck is attached to the end of the neck. The neck surface will this way be automatically protected from wear or smearing.

order to insure that the neck surfaces always get lubrication.

Distribution of Load

In practically all the hot rolling mills running on our bearings at the present time, two spherical

FIG. 10—Continuous four-high cold rolling mill with 32"x39" back-up rolls and roller bearings according to Fig. 7.

roller bearings have been used side by side on each neck for carrying the radial load. One of the reasons why the results have been so consistently excellent is that self-aligning roller bearings have been used. We all know that it is practically impossible to machine all parts absolutely accurate and that that is the case whether it be the bearings themselves, the housings, or necks. All bearings are made to certain tolerances for both the bore and O. D. and also with certain tolerances for internal clearance. Therefore, the distance from the bore surface to the O. D. surface will not be exactly the same in all bearings.

Suppose, therefore, that we get the quite exaggerated conditions shown in Figure 7 at the left. Here the neck is shown parallel with the bore in the housing but only the one bearing carries the load while the other does not carry any. When the load is applied on the housing as illustrated, there is certainly a force couple applied on the housing, tending to tilt the housing over on the other bearing, but if the bearing that is loaded is stiff there will be resistance to this tilting, causing peening in the bearing and considerable reduction of life. As, however, the bearing is self-aligning, the outer race of the bearing can tilt over the rollers quite freely and allow the housing to tilt so far that it will contact the outer race on the other bearing, as illustrated to the right in the figure. At the same time the distance between the two inner races or outer races, depending upon whether loose or tight fit mounting is used, will be reduced somewhat, which easily will be the case as they are not clamped but can slide axially. The load must, therefore, always be applied on the rollers exactly as is wanted, quite independent of the tolerances to which the various parts are made or independent of deflection of the roll neck. The effect will be eliminating of extra overload in any part of the bearing; and as the life is proportional to the third power of the load, it is then easy to understand that the absence of unexpected overloads in any part of the bearing will affect the bearing life quite considerably.

Lubrication

There is one thing I have not touched upon yet and that is the method of lubrication. In the first mills built in 1922 and 1923 we had some trouble from the fact that water entered through the seals into the bearings and caused corrosion. We tried different types of seals using packings, and also using continuous grease feeding in order to get the grease to force the water out through the seals. We were unsuccessful until we found quite another method. In 1924 we started to use soluble oil which will emulsify in water so that the water is prevented from causing corrosion. Laboratory tests have proven that even a mixture of only 2% soluble oil and 98% water is sufficient for lubricating the bearings and protecting them from corrosion. This percentage of water is certainly an extreme and should not be allowed in actual application. We started to lubricate a number of bearings with this soluble oil but found some bearings damaged from heat and we could not find any other reason than that too much water might have entered the bearings and splashed the oil away entirely. This was overcome by mixing soluble oil with non-soluble grease, 50% of each. If water enters a bearing lubricated with this mixture, the soluble oil may be splashed out gradually but enough non-soluble grease will always remain in the cage pockets, etc., to lubricate the bearings. The

FIG. 11—Reversible cold rolling mill with 37½"x48" back-up rolls.

only thing that can happen in this case is that the rust protection is lost, but as long as the mill runs that is not dangerous; and if the bearings are lubricated every time the mill is shut down for some time, they will be well protected again. This method has been used since 1925 in practically all hot rolling mills equipped with our bearings, and where this method has been used correctly I have not found a

single case where the bearings have been corroded. It is, of course, necessary to relubricate the bearings comparatively frequently in cases where plenty of cooling water is splashed over the chocks.

Benefits Obtained

The experience from all the hot rolling mills now running on our bearings has proven that many important advantages are gained from the use of these bearings. Even in cases where the most modern type of force lubricated metal bearings have been used the power saving with roller bearings has been between 35 and 40% in roughing down mills, about 40% in finishing rod mills and up to 50% in finishing strip mills. This saving means not only reduced power cost but also that the output can be increased in present mills where the motor already is loaded to 100%. On the other hand, when building new mills the driving equipment need be built for only 60 to 65% of the torque formerly required in a plain bearing mill; and, therefore, motors, gears, flywheels, etc., can be reduced in size and weight, thereby effecting a considerable saving in initial cost. That refers more generally to continuous mills where a number of gears and pinion stands are needed, but primarily to the two-high reversible blooming mills. In the latter the cost of a mill motor and converter is so high that a reduction of only 30% of the torque reduces the cost of the electrical equipment to such an extent that the roller bearings for the necks can not only be paid from that amount but even a net saving result. Such a blooming mill has been built in Germany for our steel mill in Sweden.

The next advantage with roller bearings is that they are extremely rigid and are not subjected to wear. This is very important not only in cases where it is necessary to roll as accurately as possible, but it will also considerably affect the output and reduce the percentage of scrap. The economy of the rolling will thus be increased so considerably that in most cases the cost of a changeover from plain bearings to roller bearings will pay for itself in a very short period of time. We have had cases where the application of roller bearings to wire rolling mills has required new rolls and new stands to be installed; nevertheless the power saving, the increased value of the more accurate product, increased output and reduced scrap paid for the changeover in about one year's time. I have handled so many cases of this kind that I do not hesitate to say that a finishing rod mill without roller bearings is not up-to-date.

Cold Rolling Mills

The first time our spherical roller bearings were used in cold rolling mills was in England in 1923, where the bearings were applied to a number of ordinary two-high cold rolling mills. It was immediately found that the power saving was quite considerable and also the absence of heating from the bearings improved the rolling very much.

At that time no information for determining the loads in cold rolling mills was available and we, therefore, started to make a number of systematic measurements when rolling a number of different materials such as mild steel, steel of different carbon content, brass of different kinds, bronze, copper, aluminum, etc. Not less than 3000 different measurements were made when rolling the various materials in different thicknesses with different reductions at different speeds and with different lubrication between the roll and material. In order to get the results of all the 3000 different tests in such shape that they could be generally used for calculating loads in any cold rolling mill, we prepared a number of diagrams which have been distributed and which are now used as the ordinary basis for load calculations by practically all mill builders, in Europe and to a considerable extent also in America.

Bearing Designs

I do not want to take the time to describe the first applications made in cold rolling mills but will discuss the designs which have been used for the back-up rolls in hundreds of cold rolling mills. In stands with back-up rolls, the diameter of the back-up rolls depends mostly upon the sizes of the bearings. It is, therefore, certainly most important that the bearing design be made so that a maximum capacity can be obtained within a minimum diameter as is the case when two spherical roller bearings are used side by side and mounted in a way similar to that already described for hot rolling mills. From 1928, when the first cold rolling mill with back-up rolls was put in operation in Germany, up to 1932, we used the design according to Figure 8. One of the bearings on each neck was here applied on a tapered neck and the other on a tapered sleeve. This mounting has been used in hundreds of mills most successfully. The load is applied on the bearing housing in the same way as in the hot rolling mills so that the housing can align itself to the neck. For locating the roll to the stand the one bearing housing for the top roll is located to the adjusting screw and one housing for the bottom roll to the bottom of the stand. The other housings are made free to float in the stand. The result is that when the roll neck deflects the bearing housings are free to tilt. No other means for fixing the locating housing to the stand have been found necessary.

In connection with the improvement of the loose fit mounting for hot rolling mills, we have also, during the last years, used a loose fit mounting for back-up rolls in cold rolling mills according to Figure 9. In order to assure a sufficient oil supply for the neck surface we have devised a ring fastened to the end of the neck, which goes down into the oil in the bottom of the housing and carries the oil up to a scraper, where the oil is scraped off and led into the center hole in the neck.

In order to make a mill with back-up rolls as cheap as possible, it is, as already mentioned, most important to use roller bearings with a maximum capacity in relation to the outside diameter. If American and European practice were compared in this respect we would find that the European mill builders in most cases load their mills more heavily in relation to the roll diameter and the reason that they can do this seems partly to be that they in most cases have used our design and partly heavy bearings on each neck.

The modern design of cold rolling mill is based upon the use of roller bearings and I do not need to explain why roller bearings have been so widely used in cold rolling mills.

Up to the present time our spherical roller bearings have been applied in not less than 448 stands in reversible and continuous four-high and cluster cold rolling mills and 253 two-high and three-high cold rolling mills; that means 701 stands in cold rolling mills. They have also been applied in 2 stands in blooming mills, 262 stands in merchant bar and rod mills, 82 stands in continuous wire rod mills, with delivery speeds up to 4550 FPM, 109 stands in looping and continuous strip mills with delivery speeds up to 3340 FPM, 61 stands in tube, piercing, and reeling mills, or 516 stands in hot rolling mills. The total number of stands now in operation with our bearings is 1,217.

A SELF-ALIGNING DEVICE FOR THE WORK ROLLS OF FOUR HIGH MILLS

By J. H. HITCHCOCK,
Morgan Construction Company,
Worcester, Mass.

Paper presented before the A. I. & S. E. E. Spring Engineering Conference held in Youngstown, Ohio, April 24 and 25, 1935.

A prerequisite to the successful operation of four-high mills is correct alignment of rolls. If either work roll is not parallel to its respective backing roll, rotation of the rolls under load produces a force which tends to move the work roll and backing roll endwise in opposite directions. Since the backing roll bearings are usually clamped more securely to the roll housings, the work roll in most cases is more likely to be moved. The magnitude of the axial force, determined by the vertical load and coefficient of friction between the rolls, as well as by the degree of misalignment, has been sufficient in numerous cases to rupture sturdy clamping devices and push a work roll completely out of the roll housing. It is conceivable, of course, that clamping dogs and bolts may be made strong enough to keep the rolls in place even with considerable misalignment, but in that event the forces resulting from misalignment produce unnecessary loads and dangerous stresses in the roll neck bearings. Consequently, misalignment of rolls is recognized as a very objectionable condition.

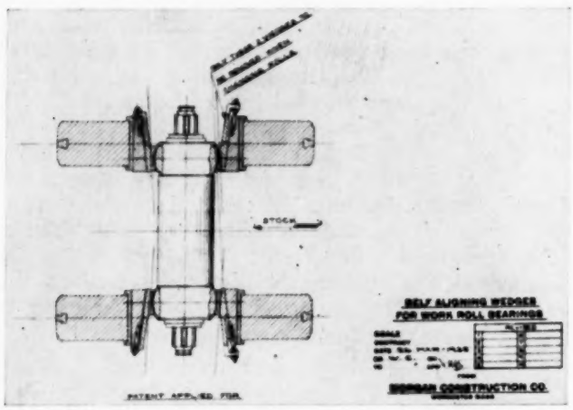


FIG. 1

Positive alignment of rolls can be assured by use of the simple and ingenious device which is to be described. This self-aligning device is illustrated in Fig. 1, which represents a horizontal section through a four-high roll housing at the elevation of the pass line, looking down upon the lower work roll and its bearings. Each work roll bearing is mounted between parallel wedges, so arranged that axial movement of the roll changes the alignment of the roll axis. No restraint whatever is imposed upon the work roll bearings with respect to endwise movement, except that in moving they must follow the slightly diagonal paths established by the parallel wedges. The bearing casings are fitted at the sides with hardened steel plates having cylindrical outer surfaces. These cylindrical plates may be permitted to bear against the wedges themselves, in which case the wedges should be hardened; or auxiliary plates having cylindrical seats, as shown in Fig. 1, may be interposed to provide a wider surface of contact.

The operation of this self-aligning device is based upon the principle that the forces which result from misalignment can be used to align the rolls properly. From the foregoing statements it is evident that no appreciable axial force can be applied to the work roll without causing it to move endwise, carrying its bearings along between the parallel wedges. This endwise movement and the accompanying change of alignment, if the inclination of the parallel wedges is properly established, places the work roll in accurate alignment with its respective backing roll and eliminates the axial force which initiated the movement.

It is pertinent to note that the parallel wedges constitute no handicap to the operation of changing rolls. Removal of the longer wedge on each side of the roll housing provides ample clearance for withdrawing the work roll with its bearings and installing a new roll and bearing assembly. The removed wedges can then be replaced at the same setting, as indicated by the inner nut on the clamping bolt, or if necessary they can be drawn in further to eliminate lost motion. The opposite wedge on each side of the roll housing can be left in place permanently.

The fact should be mentioned that this device is not applicable to four-high reversing mills, nor to

the small middle rolls of three-high mills which roll in both directions. When the direction of rolling is reversed, the direction of the axial force due to misalignment is likewise reversed; so that the endwise movement of the work roll and its bearings, instead of correcting the misalignment, would accentuate it.

After conducting comprehensive experiments and applying for patent protection, the Morgan Construction Company last year placed this self-aligning device in active operation on a small four-high cold strip mill which is likewise equipped with Morgoil bearings. This unit, which is illustrated in Fig. 2, has operated consistently in a most satisfactory manner, and has demonstrated in practice the advantages of positive roll alignment.

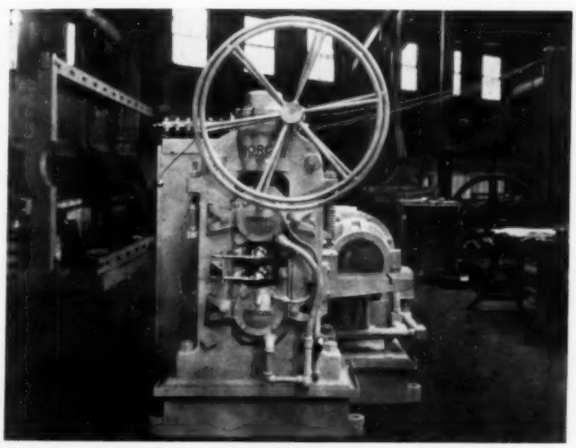


FIG. 2

Another useful device which has been developed for use with Morgoil bearings on two-high mills is the adjustable bearing clamp, illustrated in Fig. 3. This device is designed to permit precision axial alignment of passes on mills rolling shapes. With Morgoil bearings all axial thrust loads in both directions are absorbed by a double acting thrust bearing built into the Morgoil bearing on the working end of the roll so that no clamps on the drive side of the housing are necessary. The clamping device, as shown, is constructed with two pairs of jaws hinged to heavy brackets attached to the housing posts. The jaws of the upper pair act on the outer face of the ears on the bearing casing, while the lower jaws engage the inner face. The jaws of each pair are connected together by a heavy turnbuckle. Axial adjustment of the roll is readily made by slacking off on one turnbuckle and taking up on the other, or vice versa. Inasmuch as one turnbuckle is always in tension while the other is always in compression, all backlash in the hinge pins is eliminated and positive alignment can be maintained.

This type of clamping device affords several distinct advantages.

1—Due to its parallelogram construction, it is impossible for the roller to cramp the bearing in the housing window, as the bearing is always free to align itself correctly in spite of the fact that it is always rigidly held endwise.

2—Roll changes are made more readily than with the customary clamping dogs. As shown in Fig. 3, the turnbuckles are slacked off only a sufficient amount to permit the removal of one hinge pin at the end of each turnbuckle. This frees the entire clamping device, which is then swung clear of the bearing casing as shown in the view in the upper right-hand corner of Fig. 3.

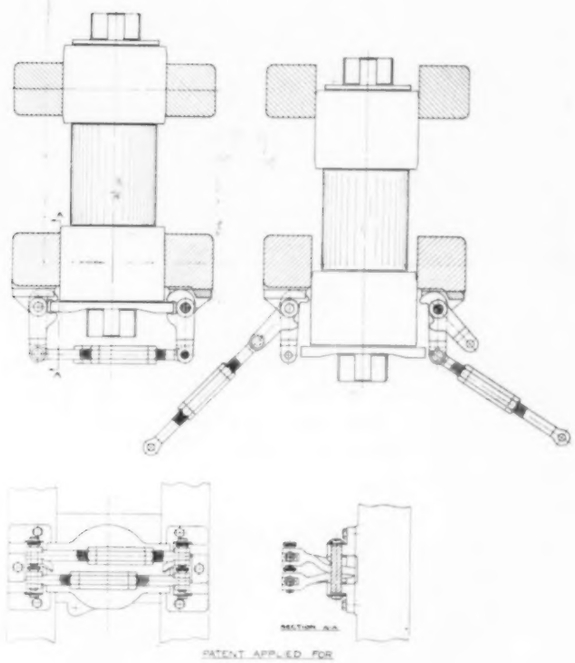


FIG. 3

3—The position of the turnbuckles in relation to the housing makes them freely accessible when making adjustments. In addition, only two applications of a wrench are necessary, as against at least four or more when making adjustments with the conventional type of clamping dogs.

INFLUENCE OF ROLL NECK DEFLECTION ON LIFE OF ANTI-FRICTION BEARINGS

By A. H. FRAUENTHAL
Bantam Ball Bearing Co., South Bend, Ind.

Paper presented before the A. I. & S. E. E. Spring Engineering Conference held in Youngstown, Ohio, April 24 and 25, 1935.

During the developmental period of mounting anti-friction bearings on rolling mill necks, a considerable amount of trouble was experienced. Many of these older mills although since revised continue to show poor bearing life. There are several reasons for the trouble.

A. H. FRAUENTHAL

Rolling pressures were calculated from a relatively small amount of measured data. Methods of pressure measurement were less advanced than at present and there is still room for improvement.

Operators quickly discovered the economic possibilities of more severe rolling with anti-friction bearings with the result that rolling schedules quickly exceeded the capacity of the equipment.

This condition still exists and probably always will. There is a particular problem at this time with so many new alloys being brought into commercial importance and with the methods of rolling them still in more or less experimental stages.

However, the greatest difficulty was caused by a lack of appreciation of the severe effect on the bearings of roll neck deflection.

This causes concentration of the load on a small portion of the bearing and is the major cause of roll neck bearing failure today as it has been in the past.

As a result of failure to compensate for this condition, it has been necessary to continually increase the size of roll neck bearings until the capacity of the bearings has become sufficiently great that a small portion of the bearing is capable of carrying the load.

This results in larger roll diameters and increase of other mill parts in proportion so that it now seems that each succeeding mill is larger than the last built for the same general purpose.

Roll diameters have already reached the point where their production in the foundry is a major problem and in one case at least, more than a year's experience in producing a certain size roll has not resulted in the ability to produce successful rolls on the first attempt.

Furthermore, larger rolls are constantly being considered to the extent that will at least greatly tax the present status of roll foundry practice. This idea was previously expressed in May, 1932, by Mr. Lloyd Jones in a paper before this Society.

It seems clear that if roll neck bearings can be arranged so that the entire bearing instead of only a small portion is operative, that much smaller bearings can be used to give satisfactory life. Likewise, life will become extremely long with the large size bearings in use on the most modern mills.

The economy resulting from this condition is self-evident.

An examination of bearings that have been in service especially on bottom rolls shows that the greatest portion of the rolling load has been carried on a short length of the bearing. This short length is located toward the inside of the mill and is the portion of the bearing nearest the roll barrel.

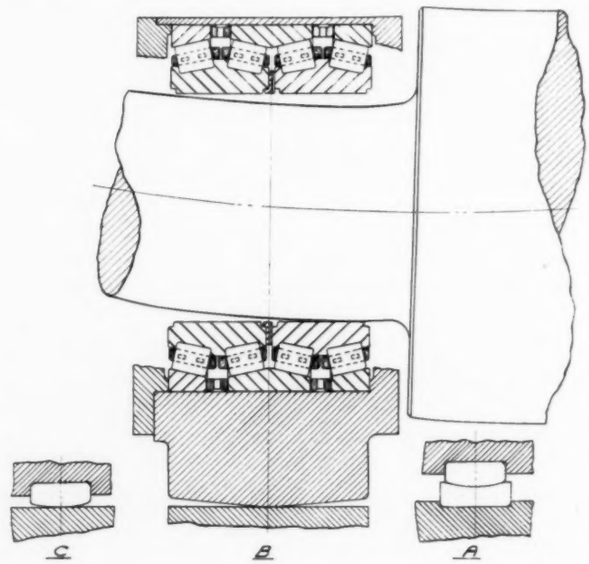


FIG. 1

The reason for this lies in the fact that the rolling load produces a considerable deflection in the roll body and especially in the roll neck, with the result that if the bearing housing does not self-align the load is carried on the edge of the bearing nearest the roll body as shown exaggerated in Figure 1.

This condition is now so universally recognized

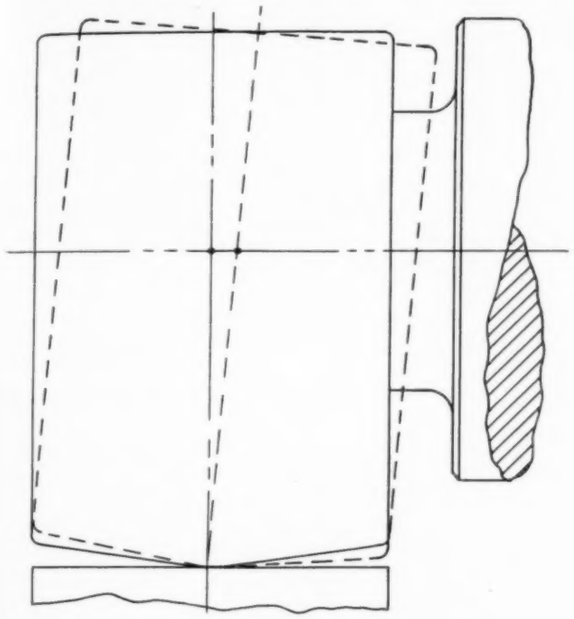


FIG. 2

that various devices have been tried to provide some means for self-alignment of the chock to bring the angle of the bearing coincident with the angle of the neck.

On the early mills, the chock bottoms were flat, these flat bottoms laying on the flat bottom of the housing window. Obviously this permitted no self-alignment of the chock.

The several designs used to improve this condition while differing in detail fall into one of the three classes shown in Figure 1.

The method shown at A requires a sliding of the male spherical block in the female spherical block to permit chock movement. This sliding never takes place due to the extremely high friction. Any attempt to lubricate these surfaces fails because of lack of the fundamental requirements for formation of film.

The method shown at B is a virtual knife edge and in common with the method shown at C has as its object a rocking action to permit the same angularity in the chock as the deflected roll neck.

A simple analysis of this action is shown in Figure 2 from which it is clear from the horizontal displacement of the bearing center that to obtain rocking action it would be necessary for the roll to shorten. As this is impossible no rocking action can take place.

To obtain self-alignment it is necessary for the bottom of the chock to move outward by sliding on the housing under load.

Again it is obvious that friction is too high for any such sliding to take place. Observation of a number of mills, both wide and narrow shows that there is no sliding.

However, compared with the old method of mounting a flat bottom chock on the flat bottom of the window, there is considerable value to the knife edge mounting.

Without the knife edge, that is, with the chock supported on the bottom for its entire length, the deformation of the chock under the concentrated load on the end of the bearing is limited to the elasticity of the column of metal under compression and experience has shown that with this mounting bearing failure takes place rapidly.

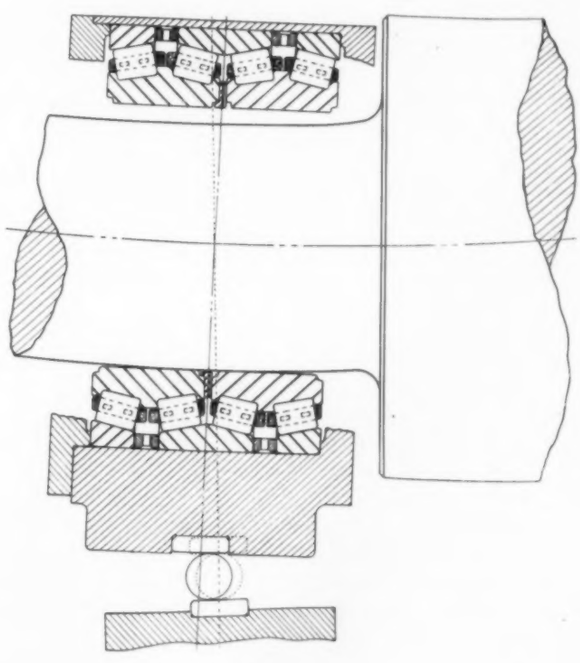
When the chock is made knife edge, the inside end of the bottom is not supported by the mill housing and consequently the deformation of the chock is only limited by the much greater elasticity of the considerable length of metal under tension. Thus stretching takes place relieving the concentration of stress and improving bearing life.

This explains why in some cases better bearing life is obtained in old mills where the chock is rather thin on the load side than in more modern mills having very thick chocks on the load side.

Another method of construction for heavy mills is that of two self-aligning bearings mounted on the same neck. To obtain self-alignment of the chock it is necessary for the outer races to move endwise against static friction under load.

For a chock to self-align it is necessary in every case to overcome static friction under the mill load and in every case the friction load is far too high.

For a bottom chock to self-align it is necessary



PATENT APPLIED FOR

FIG. 3

for the bottom to move outward and this can only be accomplished by anti-friction means.

Such a device has been developed by our company and consists of a single roller located between hardened plates on the center line of the bearing transverse to the axes of the rolls.

Figure 3 shows how this roller permits the out-

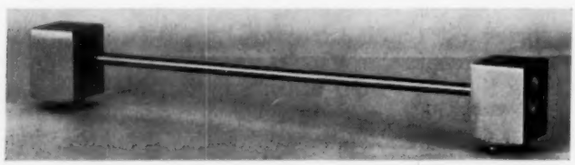


FIG. 4

ward motion of the load side of the chock and the tilting of the chock to produce an angularity of the bearing and its housing to exactly compensate for the angularity of the roll neck. It will be noted that the bearing center is not displaced and that the chock clamp can be placed at a neutral point where it will not interfere with the action.

It is obvious from the anti-friction nature of the device that it will be impossible to place a heavier load on one end of the bearing than the other without tilting or self-aligning the chock.

The above should be particularly borne in mind when it is further considered that the curvature of the roll neck as well as the angularity tends in the conventional mounting to concentrate the load on the bearing.

A model to demonstrate the poor distribution of load with the conventional mounting and the correction of this condition by use of the roller aligner has been made.

The model consists of two small replicas of roller bearing chocks with knife edge load side in which the roller bearings have been replaced by rubber plugs. A comparatively slender rod is used to represent the roll so that it can be readily deflected for demonstration purposes by hand pressure.

When the roll is deflected the chock does not rock and the inside end of the rubber plug is severely deflected.

Inserting a roller under the chock permits the chock to rock and relieves the deflection on the end of the rubber by carrying the load over its entire length.

Photograph of the roller aligner model is shown in Figure 4.

A secondary advantage of the roller aligner lies in its permitting expansion and contraction of the roll to take place on anti-friction motion.

In taper bearing mountings one chock is allowed to float or the inner races are floated on the neck. In either case expansion and contraction takes place by a sliding motion. In the case of most straight roller bearing mountings the sliding is endwise across the rollers.

While smaller in the case of straight roller bearings, the sliding friction involved introduces temporary heavy thrust loads.

This is eliminated with the roller aligner and should result in an increase in life particularly with taper bearings where the thrust load is so greatly magnified when converted to radial load.

Main parts of the roller aligner are shown in the photograph Figure 5.

The method of installing can be varied to suit various conditions, one design being shown in Figure 6.

In all cases the plates and rollers are hardened and ground Bantam high carbon chromium electric furnace steel.

It will be noted that the top plate is set in a groove in the chock and held in position by a small clamp at each end engaging a groove in the end of the plate. The bottom of the chock extends below the rolling surface of the plate to protect it when the chock is standing on the floor.

The bottom plate is set on the bottom of the housing window and held in position sideways by the machined castings which also hold the centering springs.

These centering springs and plungers are simply

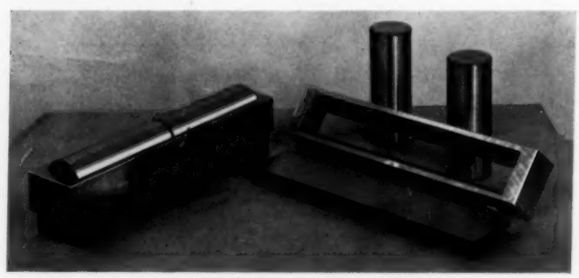


FIG. 5

to hold the roller in a central position during mounting of the roll and chock into the mill and are so constructed that they permit the roller to move in either direction.

The roller is held in a cast bronze cage which is so designed as to hold lubricant around the roller in the standard Bantam lubricage design and has a flange extending over the end of the bottom plate to limit endwise motion of the roller.

While the essential purpose of this device is to permit anti-friction self-alignment for the roller bearing, it will be noted that the roller can be designed to act as a safety device or breaker in case some accident temporarily throws the full horsepower of the drive or screw down motors into the mill.

In this emergency the roller would crush and in the arrangement shown the chock could drop ¼" before meeting a solid support. It is considered that this ¼" is sufficient to clearly indicate to the operator that something is wrong and is not a sufficient distance to cause damage by one side dropping when the other does not.

The necessity of sealing the device has not yet been established, however, a simple rubber coffer dam has been devised.

It is sometimes questioned whether or not a single roller can support the whole load. It is brought

out that in a bearing a large number of rollers are required to support the same load.

It should be borne in mind that in a roller bearing a relatively small number of rollers are in the load carrying zone at any one time and one roller carries most of the load in the load zone. This is shown in Fig. 7.

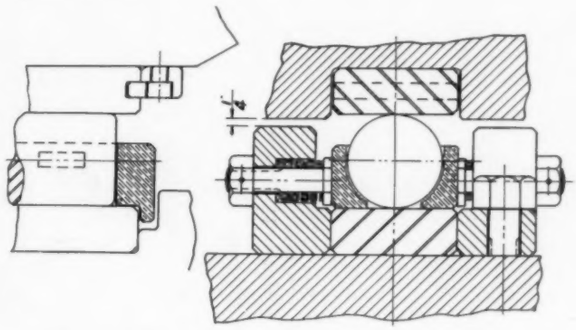


FIG. 6

Furthermore, there is the factor of fatigue to consider in the roller bearing because of the relatively high rolling speeds and large number of stress reversals, whereas in the roller aligner the roller because of its very small and infrequent motion is under static load.

It should also be considered that it is possible to use a roller much longer in a roller aligner than can be used in a roller bearing and likewise the diameter of the roller is only limited by the available space in the mill.

While there are several ways of figuring the capacity of a single roller under load between flat plates, a single example by one method is given.

For a 3,000,000 pound load, we are using a roller 5" in diameter by 24" long. Because a roller bearing of this capacity will usually have an outside diameter of over 40", there is space for a roller nearly 40" long, hence the above roller dimensions do not by any means indicate general limitations.

Tests conducted by the Bantam Ball Bearing Company show that the ultimate crushing resistance of large diameter rollers is 100,000 pounds per square inch projected area. Considering the short roller above mentioned which has a projected area of 5" times 24" equals 120 square inches, the ultimate crushing resistance is 12,000,000 pounds.

As this roller will only be stressed at 3,000,000 pounds, there is a factor of safety of 4. Some six months experience with this roller aligner has developed no trouble due to flattening of rollers or brinelling of plates and there is usually space to permit a roller having about twice this safety factor.

While it is only possible at this time to give a preliminary report on the success of this device, it is interesting to note that readings taken with dial indicators show that under heavy loads chocks equipped with the roller aligner will self-align to an angle equivalent to ten thousandths of an inch (.010") per foot, whereas the same chocks with a conventional mounting and under the same load did not self-align at all.

This measurement was taken on a very wide mill. Similar measurements taken on a compartively narrow mill (24") showed a maximum chock angularity of .0125" per foot. This indicates that any greater stiffness in a narrow mill does not react to the advantage of the bearings as far as load distribution is concerned and the roller aligner is just as necessary on a narrow mill as on a wide mill.

It does not appear to be so necessary to use this device on top rolls because the screw and surrounding parts of the mill frequently have an inherent looseness and flexibility which permits the outward movement of the load side of the chocks so that self-alignment of the top bearing may take place on the conventional mounting. A period of time will be required to establish the necessity for the roller aligner on top chocks.

It is of interest to note that steel mill records show that there is much less trouble with bearings that are continuously used on top rolls as compared with bearings continuously used on bottom rolls. It is clear from examination that this condition is due to better load distribution obtained on top rolls than on bottom rolls with conventional mountings.

Although we have always explained the superior wearing qualities of top bearings by the above theory, which has now been proven by actual measurements taken on operating mills, there have been two other opinions expressed on this subject as follows:

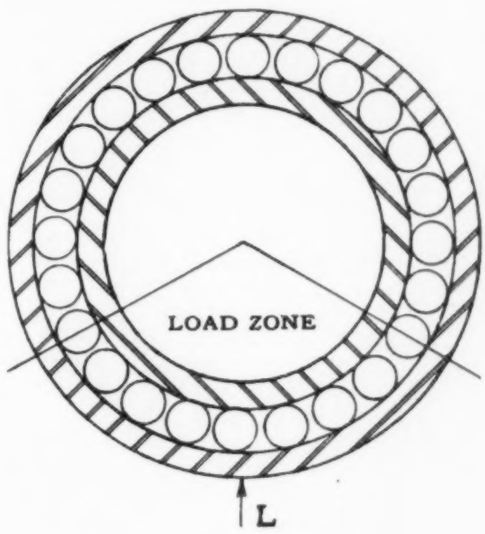


FIG. 7

(1) It has been stated that on top rolls, due to their positions, very little, if any, water and dirt gets into the bearings, whereas on the bottom bearings the water can run in by gravity and the majority of it will get into the bearing on the inside end.

(2) Bottom bearings have more load because weight of roll and chocks must be added to load on

bottom bearings whereas this dead weight is deductible from top bearings.

An examination of bearings operated on both bottom and top rolls under many different conditions and many different mills indicates the fallacy of the water and dirt theory. It is quite clear that the damage to the bearings is done by load and not by corrosion and dirt. The difference in appearance is very clear to those familiar with such details.

Dead load is very small as compared to rolling load and the additional dead load could not possibly account for the much more rapid wear of bottom bearings as contrasted with top bearings.

As a further indication that deflection is chief cause of failure we have the fact that changing chocks from plain flat bottom to knife edge did to some extent ameliorate conditions.

Consolidating present experience, we come to the following conclusions:

1. Roll neck bearings fail mainly because of poor load distribution.
2. Many top roll mountings are favorable because of their flexibility.
3. No past method of bottom roll mounting permits self-alignment due to friction conditions.
4. The roller aligner accomplishes self-alignment and good load distribution by its anti-friction character.

Since writing the above, a further investigation of some of the latest 4-high strip mills has shown very rigid top mountings with consequent load concentration on the bearings. Under these conditions, it is advisable to use the roller aligner on top as well as bottom chocks.

DISCUSSION

Discussion Presented by

R. S. Shoemaker, Supt. of Rolling Mills, American Rolling Mill Company, Middletown, Ohio.
J. H. Van Campen, Engineer, Republic Steel Corporation, Youngstown, Ohio.
H. D. Robb, Pittsburgh District Manager, Industrial Division, Timken Roller Bearing Company.
S. M. Weckstein, Asst. Chief Engineer, Timken Roller Bearing Company, Canton, Ohio.
H. H. Talbot, Chief Engineer, United Engineering & Foundry Company, Pittsburgh, Pa.
J. H. Vohr, Supt. of Hot Strip Mill, Youngstown Sheet and Tube Company, Youngstown, Ohio.
A. E. Miller, Asst. Gen. Supt., Allegheny Steel Company, Brackenridge, Pa.
F. J. Thomas, Lubrication Engineer, Republic Steel Corporation, Youngstown, Ohio.
A. W. Steed, Supt. of Maintenance, American Rolling Mill Company, Middletown, Ohio.
J. L. Young, Asst. Mgr., Industrial Division, Timken Roller Bearing Company, Canton, Ohio.
A. H. Frauenthal, Engineer, Bantam Ball Bearing Company, South Bend, Ind.
G. Palmgren, Chief Engineer, SKF Industries, Inc., Philadelphia, Pa.
J. H. Hitchcock, Engineer, Morgan Construction Company, Worcester, Mass.
J. L. Miller, Asst. Chief Engineer, Carnegie Steel Company, Youngstown, Ohio.
G. S. Warren, Chief Engineer, Sharon Steel Hoop Company, Sharon, Pa.

R. S. Shoemaker: It is a very great pleasure for me to be here and see a number of my old friends. I haven't had this privilege for several years. I have been pretty busy, like most of you, trying to keep our mills out of the red.

Thinking back five or six years ago, when large strip mills first came into vogue, as most of you can remember, we had a lot of trouble. Our first trouble was with the rolls. You just couldn't get rolls that would stay in the mill. They would break faster than you could buy them or cart them into your plant. In other words, I think our roll makers were asleep at the switch.

However, it wasn't long before it was possible to buy rolls that really would stay in the mill. As Mr. Palmgren said, "A mill may be designed for a certain gauge and the first thing you know you are rolling five or six gauges lighter than that." That passed the buck to the roller bearings.

I am very glad to see that the roller bearing men are coming to the front now and are searching for ways and means to bring their roller bearings up to the rolls.

The idea of relieving strains after having used roller bearings for a certain length of time and adding to their life, appeals to me very much. We have been hearing something about it and thinking about it. I think we may try it out in our mills from now on.

In the last paper, the anti-friction self-aligning for the bottom roll is certainly a very decided step forward. I should think that that scheme has a great deal of merit. For you fellows who haven't yet built your strip mills, it is very fine. You can apply it. But I would like to ask the author if it is possible—I hardly believe it is—to apply it to an old mill. It looks to me as if it would require boosting your bottom roll too high.

From the only dimension that was on the drawing, a quarter of an inch, I judge that the assembly would be between four and five inches. I don't know how you could get it under an old mill.

J. H. Van Campen: I don't know who is the father of these rejuvenating tanks, Mr. Keener or Mr. Robb. However, suppose we have a bearing where the load zone is fatigued and needs rejuvenating. Also we have a zone of the bearing that is not fatigued. The question in my mind is, if this re-

juvenating in drawing these bearings back, whether or not there would be a distortion in the races.

I know that the manufacturers of roller bearings have quite a problem in holding distortion to certain limits. First, they will rough turn and then rough grind, leaving a certain amount of metal on the races for a finished grinding. Then they will heat treat them and finally finish grind and in a number of cases, the races just don't true out. I am wondering that if in the drawing back, there wouldn't be a tendency in relieving the strains for the bearing to draw out of round. It wouldn't take much drawing out of round until a mechanical crew would not be able to replace the races back into the chucks.

I would like to have an explanation covering this question.

H. D. Robb: This is a comparatively new development with us. We have been doing it only a short time, but we find they do not go out of round. The fact of the matter is we have had enough roller bearing experience to know that sometimes the chocks are not entirely uniform and the bearing becomes out of round by following the shape of the chock, but when you put the bearing in the tank it comes back toward its original roundness.

J. H. Van Campen: My impression was that, due to internal strains in that load zone being relieved against the load zone where we will say there was no work done and where there are no strains, there would be a tendency to draw the race in an egg shape. That was the question in my mind.

S. M. Weckstein: We have checked quite a large number of bearings of different sizes. We find that both the inner races and the outer races go out of round. The inner races do not go out of round as much as the outer races.

Careful measurements are being made on bearings which have been in service and which are returned for reconditioning. These measurements are made on the parts as received and also after they have been treated in the oil tank. We find that there is always a difference in the readings before and after the oil treatment. In other words there seems to be a release of the stresses which tends to reshape the races. We have not been able to bring any of the races to the original manufactured roundness.

J. H. Van Campen: Take a four-roll bearing assembly. Do you attempt to clamp that complete assembly in order to hold it as one unit so as to give the same effect as used in the manufacturing of smaller bearings, which are heat treated or drawn over a plug. Do you attempt to clamp the complete bearing assembly and let the rolls act as a plug for the races or is the assembly free?

S. M. Weckstein: In the manufacture of the bearings the races are heat treated and individually hardened on plugs in order to keep them round. The individual parts are drawn or tempered during the manufacturing cycle. When bearings are returned for reconditioning they may be treated in the oil tank in their assembled form. It is more advisable, however, to break the bearing down for a complete physical examination and then treat the individual parts. The temperature of the oil is closely controlled so that the drawing temperature of approximately 350 degrees F. is not exceeded.

H. H. Talbot: I don't know that I have anything to say except that I have enjoyed the papers very much. The point that has been running through my mind about re-heat-treatment has been pretty well answered.

The self-aligning device has been under consideration for some time and with reference to such existing installations, we are awaiting further information. We have heard some reports to the effect that the plates and rollers show signs of "Brinnelling." Theoretically I think the idea of the device is very fine.

J. H. Vohr: We are pretty well satisfied. However, I would like to ask the Timken Company what anticipated extra life we may get out of the bearings.

S. M. Weckstein: I am sorry to say I don't have an answer.

As a matter of fact the subject has been brought up to us by a number of people who have a small number of bearings in the plant and who cannot justify the purchase of equipment for drawing the bearings. They have asked us to rejuvenate the bearings for them. We have been unable to find out from them just what they expect after the bearings have been rejuvenated.

We hesitate to start in on this because we ourselves do not know what to expect. Some one may send in some bearings for which there will be a small charge for the labor required in rejuvenating them. These bearings may go back into service with the expectation of getting a certain life from them. If this expected life is not obtained there may be a come back on us for not having satisfactorily rejuvenated the bearings.

We know from our past experience on bearings that have come back to be repaired that their life is prolonged. We also know in our manufacturing practices that by properly drawing bearings to relieve stresses—and not only bearings but any material that has been worked on—a better product is obtained. Rejuvenating the bearings will give improved results. Just how much improvement we do not know.

A. E. Miller: I don't know that I have anything in particular to add to the discussion. However, I can't help but be reminded, in listening to Mr. Robb's paper, of the similarity of anti-friction bearings with a lot of the other equipment in the steel mill. I think a little resume of the history of the electric cranes will illustrate my point.

Back in the early days we attempted to regulate production and operate to the capacity of the crane. Then somebody made the remarkable discovery one time that steel mills were to be run to make steel and not to take care of the crane.

It seems to me that the anti-friction bearings are going through somewhat the same period. The problem of the anti-friction bearing maker is to design his bearing so that it will not only take care of the load that it is designed for but if it is to be a complete success it will have to be able to withstand the unusual things that happen in the steel mill. If this cannot be done by increasing the size of the bearing, it must be done by improving the quality of the material going into the bearing.

I think the anti-friction men are alive and awake to this. In fact, this scheme of rejuvenating the

bearing I think is along the proper line, that we may so renew the bearing to get longer life and less breakage than we are getting now.

F. J. Thomas: I would like to ask Mr. Robb if he will expand more in detail on that part of his paper referring to the use of extreme pressure lubricants. These were mentioned briefly. I would like to know whether they have any data concerning the types of extreme pressure lubricants which they have found to be most satisfactory for these large roller bearings which are operating under very heavy pressures. I would also be interested in hearing what results could be expected from their use. How much greater bearing life they have obtained from the use of these extreme pressure lubricants.

H. D. Robb: I don't know that I thoroughly understood the question. I will try to answer it. If I don't cover everything, let me know.

In this paper I was referring particularly to the first mill in which we installed a two row bearing on a back-up roll, and in this mill we had plenty of trouble. We had five or six bearing failures in the first two months of operation. We investigated thoroughly. The bearings checked satisfactorily metallurgically and were within our close inspection standards. That was at the time we developed the EP lubricant and it solved the trouble. Using those same bearings in that particular mill, we understand some of these bearings have now rolled close to a million tons of steel.

Incidentally, at the time of this trouble we built up new bearings for that entire mill, and we have been holding them ever since.

A. W. Steed: The temperatures of 325 to 350 Deg. F., used for testing bearings are rather low and I would be interested in knowing just what action, metallurgically or otherwise, takes place in the metal at these temperatures.

When a bearing is in service the rolls and races surface harden and the Brinell reading increases with the use of the bearing. Does this heat treatment reduce the Brinell increase due to work hardening. What is the effect of this treatment on aging of metal?

H. D. Robb: In making the bearings we draw them back to Rockwell hardness, around C-59 or C-60. We find after they have been in service for some time they work harden, to around C-63 or C-64, and that the steel when it is that hard is more brittle and more subject to spalling. We know this tends to bring back the original hardness and by so doing we minimize the danger of spalling.

J. L. Young: The question of the metallurgical reaction of this drawing tank operation has been raised and may I add to the statements already made by Mr. Weckstein and Mr. Robb.

After the final grinding operation in the manufacture of these large bearings we developed this low temperature draw or aging process for the relief of any grinding strains that might be set up in the final grinding operation and at the same time to give the bearings the proper hardness of Rockwell C-57-60 required for this class of work.

It is only logical to believe, based upon our various experiments in our own laboratories and in actual mill service, that if a bearing can be maintained at the proper hardness just mentioned, it will give the best life and best service. We do know from this experience that bearings work harden over a period of time and we have further found that by re-treating these bearings in this aging furnace we can relieve those cold working strains to some extent and in many cases possibly completely, depending upon the condition of the bearing at the time of aging.

We have had cases where the bearings have been brought back to their original hardness or at least within the range of specified hardness and by the relief of these cold working strains the bearings have assumed their original roundness. This eccentricity from the standpoint of cold working strains is caused by the concentration of load, especially in the area of the outer race or cup on one side only. It of course has been the practice in the past to rotate these cups at each inspection in order to present a new bearing surface in the load zone. We still recommend this practice but based up on the experiments to date we believe that in addition to that practice the low temperature draw or aging process will aid materially in the extension of bearing life.

A. H. Frauenthal: I would like to add a point to that discussion. We have been doing quite a bit of work on the reduction of work hardening of bearings in service. We have not found that by drawing back bearings even up to the original drawing temperature that we are able to bring back the original hardness.

That may be due to a difference in the steel used. The Timken bearings are made of nickel chromium steel and the Bantam bearings of straight chromium steel.

On the other hand, from the metallurgical viewpoint, I do not see how you can get back the original hardness because in all other types of work hardening we know about, for instance, in drawing of wire, it seems necessary to go to temperatures around 1200° F. to really reduce work hardening. We have been unable at temperatures as high as 450° F. for as long as twenty-four hours to bring back the original hardness.

However, even though the original hardness is not obtained, it does not mean that no benefit has been received. Stresses can be relieved without reducing hardness. This is frequently the case in the original draw after hardening.

There is an increase in atomic mobility as the temperature increases and thus the internal stresses are lessened.

The higher the temperature the more quickly and completely are those stresses relieved. It is quite conceivable that in the redraw after service you can relieve some of the stresses without very much relieving the work hardening.

For sometime we have put into practice with one customer, a redraw on all bearings returned for repair. They now do no repairing whatsoever and it is reported that the bearing cost per ton of steel rolled has been reduced. We are not sure if this is due to better repair work or to the redrawing.

In further connection with the relief of stress and the extra life that might be obtained, hardened steel may be highly stressed when ground after hardening. An analysis of the cutting action of the grinding wheel shows this to be entirely possible, and for that reason the Bantam Ball Bearing Company also redraws their bearings after grinding operation.

Mr. Shoemaker of the American Rolling Mill Company asked whether we could put the roller aligner on existing mills. It depends on the mill. We have had a roller aligner in successful operation for sometime in a mill to which it was added long after the mill was built. There is another one going forward at this time for a mill already built. As it is usually impractical to attempt to machine large housings, it depends mostly on the thickness of the chuck on the load side.

In connection with Mr. Talbot's question about the Brinelling of the roller aligner plates, some six months' experience in a very wide mill under very heavy loading has shown no Brinelling of the plates whatsoever, and no flattening of the roller.

This item can be easily controlled because the ultimate strength of the material in the loaded area is around 600,000 to 700,000 lbs. per square inch, and it does not take a very big roller to reduce this stress on any mill down to around 300,000 lbs. per square inch. This is quite safe for our type of steel and hardening because the load is static and it is only necessary to get the stress a little below the ultimate strength of the material.

We have had on one reversing mill a very slight marking of plates at the extreme end of the roller. There is no Brinelling either here or along the length of the roller, but at each end there is a slight marking to be seen, and this seems to be due to a slight tipping of the chuck when the tension is first applied to this strip.

G. Palmgren: To what I said in my paper, I should like to add that in 1923 we had about the same idea regarding the alignment of the bearing housings as now discussed by Mr. Frauenthal. Instead of rollers, however, we used hardened knife-edged supports according to Figure 12. At the end where these supports roll on a flat hardened surface the radius was made much larger than can be the case when a straight roller is used. At the other end the support was made with the same radius as the hardened washer so that full surface contact was obtained. The stress in the two carrying surfaces was here figured to be only half of what it is in the bearings. The edges could also carry the heavy loads satisfactorily and are still in use in rod and bar mills where they were applied, but for later installations we dropped them because the elastic deflection was rather high. We also found that we got just as good distribution of the load without them and that we did not need to go to that complication.

There is one point in our design I want to stress and that is, that when the bearings are applied, for instance, according to Figure 7 in my paper, the outer races are clamped endwise but the inner races are not, which means that the inner races which are fitted loosely on well lubricated necks creep slowly around the necks and can easily move sideways sufficiently to allow the bearing housings to tilt around the point where they are supported and axially located.

I should like to say also that the life of roller bearings depends on the design, the distribution of load on the bearings, the adequacy of the bearings for the actual loads, and so on. I, therefore, want again to point out that when we started this business, we first of all determined the loads very carefully and did not take any chances regarding bearing size or method of application. The result also was very gratifying. For instance, of all our bearings applied on back-up roll necks in big mills since 1928, so far as I know, we have not had one single bearing failure. I also refer to an 18" continuous two-high hot strip mill in Japan having two spherical roller bearings 11.02"x16.14"x3.86" per neck where

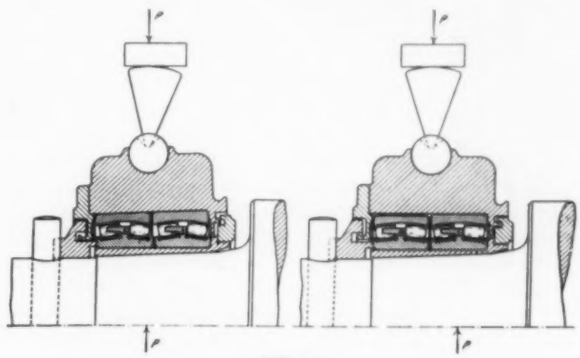


FIG. 12

they have rolled 500,000 tons of strip 8"x¼" on the same bearings corresponding to 32 million revolutions under full load in the finishing stand. Therefore, I cannot pass on the question of how to improve the bearing life that has been the subject of so much discussion here. We have not had that problem at all.

J. H. Van Campen: I would like to ask Mr. Palmgren: Of those 1200 or so mills which he has shown equipped with S.K.F. bearings on roll necks. How many of those mills so equipped are in the United States and how many in foreign countries?

G. Palmgren: There are, if I remember correctly, about 150 stands in the United States but most of them are rather small.

J. H. Van Campen: Is it not true that in the foreign mills, they do not load their mills as high as we do in this country. Their housings are not as heavy and they take a greater number of drafts for the same amount of total work than we do on our mills. The result is, that in your applications pertaining to the foreign mills perhaps the bearings are not loaded up to such heavy capacities as in similar types of mills in this country?

G. Palmgren: It is rather the reverse from what you expect. The mill builders in Europe as far as I can see economize more with the stand dimensions in order to get the unit as inexpensive as possible. For a certain work they use in most cases bearings with smaller O.D. and consequently smaller back-up rolls, which are more heavily loaded in relation to size than is customary here. They, however, in most cases use heavy S.K.F. bearings with more capacity in relation to the outside diameter and apply them so that the right load distribution is obtained.

J. H. Van Campen: Do you not contribute that as the reason for the S.K.F. bearings not having any failures, that they haven't been loaded to the capacity that similar mills in this country have?

G. Palmgren: Before we started to apply roller bearings on necks in cold rolling mills, we made not less than 3000 different load measurements and put the results together in diagrams so that we are now

able to figure the load in cold rolling mills within a margin of about plus or minus 10%. By figuring the loads carefully and also the bearing life under the estimated loading conditions, it is to be expected that the bearing life in actual service will equal that which was estimated. This way of doing things seems to me to be much sounder a method than just to take a chance.

J. H. Hitchcock: Mr. Palmgren has just said that bearing loads can be figured with an accuracy of plus or minus 10%. With that I agree heartily. However, I would like to inquire of Mr. Palmgren whether in Europe it is possible, before a mill is constructed, to determine what the rolling schedule is going to be after the mill is put into operation.

G. Palmgren: We have two ways of doing that. One is to settle the rolling schedule first and then to design a mill for that job. The other is to make a mill and then figure out what can be done in it. It is then certainly up to the user of the mill to look after his own material and use it only for the work it has been designed for. By making the necks unnecessarily strong and the bearings too weak in relation to neck diameter, the user of the mill will naturally be tempted to overload the mill, as nothing happens immediately to the bearings; but if the design is made right so that bearing size and neck diameter are well balanced the result will be when there is too much overload, the necks also will break at some time and warn the operator.

H. H. Talbot: There is a question in my mind in regard to the self-aligning device; that is, whether the necessity for such a device is as great on the cylindrical or straight roller type bearings as it is on the four-roll taper roller type; having in mind the ability of the neck to "float" axially in the straight roller type and thus to accommodate itself to a shifting of the bearing center, due to roll deflection or expansion.

A. H. Frauenthal: We have examined a good many bearings of our own and other manufacture and find that the load is concentrated on the portion of the bearing nearest the roll body, regardless of the type of bearing. We have no reason to believe that the roller aligner is less valuable on one type than on another.

J. H. Van Campen: We have heard a lot of discussion in this and various other meetings of this Association on roller bearings. One development on which I am interested and I believe will be very interesting for the gentlemen here, is mills that are being equipped with the so-called precision sleeve-type plain bearings. I think something along that line would be extremely interesting, to find out about these bearings pertaining to the various applications that have been made to date, as to their characteristics and as to how they are standing up. If there are any representatives in this meeting to represent this type of bearing, I am sure it will be a pleasure to hear from them?

J. H. Hitchcock: In regard to Morgoil bearings, there are approximately 440 in operation. They are operating very satisfactorily and with very low coefficient of friction. The power savings are considerable. In many installations they are also increasing yield. I might cite an example.

Morgoil bearings were installed on the finishing stands of a 12" strip mill in England. By power savings and an increase of yield of 1½%, they paid for themselves in less than five months, whereupon additional bearings were installed in the roughing stands of the same mill. The bearings in the roughing stands are performing equally satisfactorily. That performance is not exceptional, but is typical.

If there are any specific questions which Mr. Van Campen or others have with regard to this performance, I will be glad to try to answer them.

J. L. Miller: How about gauge uniformity?

J. H. Hitchcock: You mean from end to end?

J. L. Miller: Yes.

J. H. Hitchcock: Gauge uniformity from end to end depends on two things: the temperature distribution in the strip from end to end, and the ability of the bearings to carry the load without wear. In our bearings there is no wear, so that the only gauge discrepancy from the front end to the back is caused by temperature distribution, and that is a matter entirely apart from bearing performance.

J. L. Miller: In other words, the temperature differential in the oil feeding of the bearing.

J. H. Hitchcock: No, the temperature differential in the strip.

J. L. Miller: How about the temperature differential in the oil being fed to the bearing that is any temperature variation?

J. H. Hitchcock: There is no disparity in that respect.

L. F. Coffin: I would like to ask whether the self-aligning feature similar to that proposed by the Bantam Ball Bearing Company has been found to have value on oil or grease lubricated plain bearings. It would appear that this might prove to be the case.

J. H. Hitchcock: In most of the bearings now installed, the bearing casings are equipped with rockers somewhat similar to those which were illustrated by one of the slides on the screen. To date we have found no reason for changing that practice. Whether the flexibility of the oil film in the bearing eliminates the need for further refinement in self-alignment, I can't say. It may be that that is the case.

A. W. Steed: What type of bearings did you replace in the English mill? Were these brass or roller bearings?

J. H. Hitchcock: Mr. Steed has asked what kind of bearings were replaced when Morgoil bearings were installed in the 12" strip mill in England, of which I spoke earlier.

Those bearings were conventional open brass and babbitt bearings. The power savings averaged about 50 per cent in the finishing stands.

J. H. Van Campen: In the Morgoil bearing, here we say we have a dead mill starting up and the oil seal is broken, do you use an oil jack in the initial starting in order to start and build up the oil film in the load zone?

J. H. Hitchcock: We have never found that necessary. At one time the question was raised whether Morgoil bearings would be suitable for a cold rolling mill in which the rolls are stopped under load for gauging or other purposes.

To answer that question, we made thorough tests in our shop. We equipped a stand with Morgoil bearings, loaded it up heavily by facing the rolls against each other, and shut it down. We let it

rest for varying periods of time and measured the starting torque required to start it. The periods of shutdown varied from a few seconds to over a week-end. We found, as would be expected, that the oil film was squeezed out gradually, but the rate at which the oil film was squeezed out was quite slow, and in every case rotation of only a few degrees was required to re-establish the film completely.

Based on those experiments, we have considered it unnecessary to resort to a high pressure jack.

A. W. Steed: Mr. Hitchcock has a very neat device for the lining of the mill rolls. If this device will keep roller bearings in position so that the operator cannot get misalignment of the rolls, it will help the maintenance man's job materially, also, increase the life of rolls and bearings and reduce the necessity of heat treatment, adjusting devices, etc.

J. H. Hitchcock: You may have observed when the illustration of the self-aligning device was shown on the screen that no detail of the bearing was shown. That was intended to convey the meaning that the device can be applied to any bearing.

G. Palmgren: That design described by Mr. Hitchcock for aligning work rolls was patented by the firm Demag in Germany about 1927 and has, as far as I know, been used by them with good success.

G. S. Warren: The Sharon Steel Hoop Company of Sharon has a five-stand roughing mill in which four stands are equipped with Morgoil bearings which have been operating two or three years. We didn't put them on the No. 1 stand because it is only used once in a while. The four stands were designed for rolling 10 inches wide and are now rolling 22 inches wide. We have had no trouble with the bearings, and can find hardly any wear in most of them. We have opened them up after running them six or eight months and found at least 50 per cent of the tool marks still on the babbitt.

You know that stainless steel will take about twice the pressure that common steel does. We break rolls regularly on stainless rolling in this mill because of the difference in temperature, but so far the only damage we have done to the bearings is to batter up the face, because the rolls usually break diagonally. We had some welding and some repairing to do on the face of the chuck.

We have only lost one sleeve, and that was due to a roll breaking at about the center of the neck. We don't know how long it ran after breaking the roll.

We have definitely proved that our reduction in power is at least 50 per cent with those bearings. The mill had originally babbitt and brass bearings.

We also had on our finishing stands a greasing system which helped some, not very much. We were supposed to roll 6 and 7-inch, 20-gauge strip, and were never able to do it on plain bearings. We replaced the 6-stand, 2-high finishing mill with the four-stand, four-high mill equipped with anti-friction bearings and put the Morgoil bearings on the roughing mill, and the power reduction is about 50 per cent.

It wouldn't have been possible to have done anything like that without the anti-friction bearings on this mill. This is an actual demonstration, and not a month's trial, but was over a period of a year. We cut the power from 161 kilowatts per ton total load—that is everything including auxiliaries—to 80 kilowatts.

SUBJECTS TO BE DISCUSSED AT TECHNICAL SESSIONS AT 31ST CONVENTION OF THE A. I. & S. E. E.

SEPTEMBER 24, 25, 26, 1935, WILLIAM PENN HOTEL, PITTSBURGH, PA.

ABSORPTION OF THE PRODUCTS OF STRIP MILLS

INSULATION OF OPEN HEARTH FURNACES

INDUSTRIAL RELATIONS

DEVELOPMENTS IN THE USE OF THE OXY-ACETYLENE PROCESS IN THE IRON AND STEEL INDUSTRY

BRIGHT ANNEALING

ROOF TEMPERATURE CONTROL OF OPEN HEARTH FURNACES

PROCESSING OF FLAT ROLLED STEEL

WELDING WITH THE ALTERNATING CURRENT ARC

RUN OUT TABLE MOTORS AND GENERATORS FOR HOT STRIP MILLS

ALLOY ROLLS FOR STRIP MILLS

LUBRICANTS FOR COLD ROLLING STEEL

IMPROVEMENTS IN POURING MOLTEN STEEL

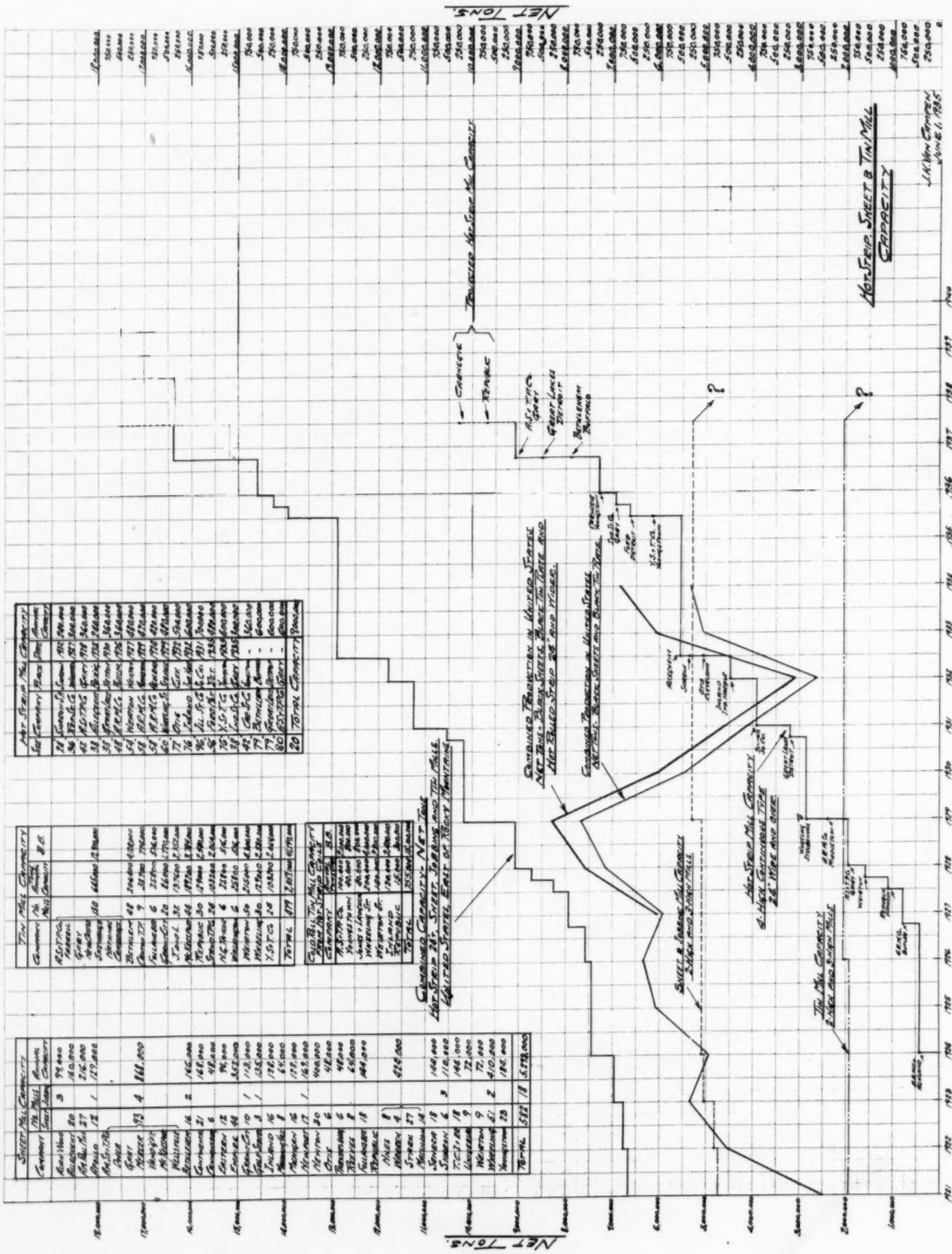
CUTTING OILS

NON-METALLIC, ANTI-FRICTION AND OIL BEARINGS FOR ROLL NECKS

DEVELOPMENTS IN THE IRON AND STEEL INDUSTRY DURING 1934-1935

MATERIAL HANDLING

WELDING AND ITS POSSIBILITIES IN THE STEEL INDUSTRY


Net Tons
Hot Strip Sheet & Tin Mill Capacity
Capacity Tandem Hot Strip Mill Capacity
Combined Capacity Net Tons Hot Strip, Sheet Bars, Slabs, Blooms and Billets
Combined Capacity Net Tons Hot Strip, Sheet Bars, Slabs, Blooms and Billets
Combined Capacity Net Tons Hot Strip, Sheet Bars, Slabs and Tin Plate
United States East of Rocky Mountains
Hot Strip Mill Capacity 24" Wide and Under
Sheet & Tin Mill Capacity 24" and Under
Tin Mill Capacity 24" and Under
Years

Herewith is presented a graphic picture of the flat rolled division of the Steel Industry as prepared by J. H. Van Campen.

WIDE STRIP MILLS

By J. H. VAN CAMPEN
Special Engineer, Republic Steel Corporation, Youngstown, Ohio

Paper presented before the A. I. & S. E. E. Spring Engineering Conference held in Youngstown, Ohio, April 24 and 25, 1935.

The wide strip mills as they are being built today have been more or less standardized in layout. I will just describe one in a general way.

A conventional 60" or 79" hot strip mill today will be supplied with either two or three slab reheating furnaces, end charging and discharging, having a hearth about 18 feet wide by 80 feet long, heating slabs 3 inches to 6 inches thick at a rate of 50 tons cold slabs per hour each.

The mill layout consists of, first, a horizontal two-high scale breaker, then a broadside stand of either two-high or four-high type with roll faces about 96 inches. This stand is used for cross rolling a slab which is usually 39 or 40 inches wide, as it comes off an average 40-inch blooming mill up to a maximum width of 72 or 74 inches in one pass.

At the front and back of this broadside mill there is provided a turn-around rig for manipulating the slab. After the broadside mill there usually follows in tandem about three stands of four-high roughing mills. These mills are usually provided with vertical edgers in front of each stand, which edgers are either built in combination with the mill stand or separate units.

The above group of mill stands constitute the roughing section, between the roughing group and the next group which constitutes the finishing sections. There is usually a gap of about 150 to 175 feet of table. The finishing section constitutes first a two-high scale breaker followed by six stands of four-high finishing mill stands, spaced about 18 or 20 foot centers.

Immediately after the first scale breaker and the second scale breaker, also possibly one or two of the roughing stands, there is always placed an adequate high pressure spray line for the elimination of scale. The scale breaker in front of the finishing section is called the secondary scale breaker because that has to finally clean the steel of all the scale before it goes through the finishing train, as from then on there is no chance for further cleaning.

The standard spray system for this type of mill operates under a 1000 pound pressure per square inch, and supplied by about two 1200 to 1500 gallon per minute pumps. There is a trick in the nozzles of these high pressure scale removers, as the water has to be directed in a very definite line across the strip rolled and no breaks in that water line to allow a streak of scale to remain on the steel, also there is a practical definite angle and distance of the nozzles from the material.

A mill of this particular type will roll strip steel in certain widths down as low as 18 gauge. Some have tried to go as low as 20 gauge, but I understand it is a pretty costly operation. These mills will require anywhere from 25,000 to 38,000 H.P. of main drive motors, and the delivery speed from the last stand will range up to 1500 to 1800 FPM.

Immediately back of the last finishing stand on some of the latest mills there is a flying shear for cutting into multiple lengths at mill delivery speed the strip as it is delivered directly out of the last stand. These multiple lengths are delivered down

J. H. VAN CAMPEN

the center runout table, shingled and piled. Other mill layouts have the flying shear possibly located down at the end of the center runout table for multiple shearing and piling. Again the strip may be transferred sideways from the center runout table onto a side run table, with the flying shear at the end of this table.

Down the center runout table from the last finishing stand and in direct line a considerable distance, there are located two coilers in tandem working alternately, that take the strip at mill speed for producing coils. There is a little question in locating these coilers the proper distance from the last mill stand, for the simple reason that if you coil strip steel too hot it is subject to what we call cross breaks. These cross breaks develop when the coil is opened up as the strip passes through a roller leveler for further processing. The inside of the layers in the coil during opening are under tension and the outside of the layers are under compression. Naturally it being soft steel, it has a reason to make what we call cross breaks.

It is the practice in these strip mills, if there is sufficient distance between the last stand and the coilers to delay the strip on the runout table before it is entered in the coilers. You can do this by allowing the strip to slow down on the runout table to the coilers. The mill, of course, keeps flowing on with the strip looping on the table. In this manner you can obtain some temperature drop in the strip before coiling. Some mills have between the roughing group and the finishing group of roll stands a delay table. I believe the Ford Mill has an air blast system in that particular section of table in order to get the proper temperature drop of strip before entering the finishing st nds.

The late strip mills are equipped with temperature recording instruments, indicating the temperature of the strip as it is delivered from the mill. This temperature is watched very closely and depends somewhat on range, varying according to what product the hot rolled strip is going to be used for. Different products require different draws or different fabricating processes with varying Rockwell hardness.

Strip that is coiled is usually delivered from the coilers onto a coil conveyor to the coil storage building. From the storage, the coils either go to levelers and shearing units for cutting to lengths and sold as plain hot rolled or hot rolled, pickled and oiled, or in a number of plants the greater percentage of the hot rolled coils go to continuous pickling units for delivery to the cold reducing mills.

These continuous pickling units have been pretty well standardized and consist of a coil box, coil opener, pinch roller, roller leveler, end crop shear, stitcher or welder for attaching the end of the next coil to the preceding coil end for continuity through the tanks. The pickling tanks are usually four in number about 60 feet long, each arranged in tandem, giving a total of 240 feet of acid bath. Between the tanks are the necessary guide rollers for directing the strip from one tank to the other. After the acid tanks and in line are two water rinse tanks, approximately 40 to 50 feet long each, one with hot water, the other with cold water. The speed of the strip through the continuous pickling units is anywhere from 60 to 100 feet per minute. As the strip is delivered from the water rinse tanks, it passes through a drier, then the weld or stitch is sheared out, then coiled for delivery to the cold rolling units for further processing.

The cold reducing mills for rolling this pickled hot rolled strip are of very large dimensions, and the typical arrangements are either three stands in tandem, provided with a coil box and entering device arranged to roll under tension between stands and provided with a tension reel on the delivery end or again a single stand 4-high mill of the reversing type, provided with a tension reel on each side. These mills require motors up to 1200 to 1500 H.P. per stand, with delivery speeds of 400 to 800 feet per minute, and will reduce cold a strip from .090 inches thick down to 0.35 inches thick in three passes and rolling coils up to 20,000 pounds in weight.

After the cold rolling reducing operation, the strip is further processed either in coil form or cut lengths, by cleaning, rewinding, normalizing, annealing, shearing and temper rolling either in coils or cut to length form, to obtain the desired surface and temper required, depending upon the grade and order to be filled for the customer.

The processing of various grades of strip steel for the trade today is of considerable magnitude. I think if we were to sum up the total, there would be around 100 to 150 different grades demanded by the trade today.

In the finishing and processing end covering strip steel, I believe there is more unpublished than there is published, regarding that part of the manufacture of strip steel. I believe if an association such as this could get the attendance to talk and discuss the various phases of processing strip steel, such as, quality of steel, heating, hot and cold rolling, finishing methods and so forth, it would be an extremely interesting subject.

When you go into the various plants, you will find one fellow doing this and that is his pet way. You go into another plant and you find a fellow there possibly accomplishing the same results, satisfying his customers, and still doing that particular thing in another way.

The growth and immensity of this hot and cold wide strip business has been appalling. It is one of the youngest branches in the field and I believe has come forward more rapidly than any other branch of the steel industry. The magnitude of it, the tonnage output, the investment, is immense.

Today in this country, as I mentioned in a small editorial of the Iron & Steel Engineer, April issue, there are eighteen of these wide strip mills. Two more of them, I think, will be authorized before the end of this year. All of these mills have roll faces 24 inches and wider. Of course, a 24 inch roll face mill cannot roll 24 inch wide strip. Twenty-four inches is the dividing line in width between the category of strip and sheets. These twenty wide strip mills that will be built or authorized before the end of this year will have a combined capacity of approximately nine million tons of steel strip in a year. Now what is going to become of the old-fashioned sheet mill, of which today, I believe, there are in this country around 580 old style two-high and three-high sheet mills, eliminating from that picture all the mills of that type that in our judgment we feel will not be operative again. The combined capacity is approximately 5¼ million tons a year. Also there are some 475 old style hot tin mills, which have a capacity of approximately two million tons, or forty million base boxes a year. And there is the development coming out of this wide strip picture which is the amount of hot rolled strip that is going into cold rolled tin black plate. Today in this country there is 750,000 tons of hot strip rolled cold in coil form, producing 15 million base boxes of tin black plate, or 36% of the total tin plate production.

In order to better illustrate this condition we refer to chart Figure 1 which shows the combined production of all the hot strip mills, which we stated was about 9 million tons, all the old style sheet mills at 5¼ million tons, and all the old style hot tin mills at 2 million tons, we have a flat rolling steel capacity for these products in this country of approximately 16¼ million tons.

According to statistics, we find in looking back to the year 1929, the best year the steel industry has ever enjoyed, the total production in this country of all tin plate, all sheets and all strip was approximately 8½ million tons.

The question in the minds of a great many steel men today is, "If we build these wide strip mills to protect our existing investment and also endeavor to keep the other fellow, our competitor from taking away the business we already enjoy, will this be a costly investment?" With 8½ million tons production in this country in 1929, and already by the end of 1935 in hot strip mills alone there will be under way a capacity to produce 9 million tons and maybe more to come, the question is, What rate will the steel manufacturer be able to enjoy in operating

these mills? It is a question that I have inquired about very much and have not received an answer to. We all say steel is being used in more and more products in household utensils, such as refrigerators, washing machines and so forth. When you come to analyze the tonnage, the amount of it is not of much magnitude. The only visible outlet on the horizon to consume large tonnages of flat rolled steel in the future is the possible development of steel houses. Whether or not that will come forward in the next five years or in the next ten years, we do not know. That looks like the largest potential market that will compare anywhere near to the automotive industry in consuming large tonnages of strip steel.

Just as an oddity, I might say, the other day from curiosity, I wondered how far all this strip steel would reach in one piece, or something like that, and I took 9 million tons, figured it out on the minimum possible gauge these wide hot strip mills were able to roll economically, nominally 18 gauge, and found that on 18 gauge strip, 12 inches wide, 9 million tons would produce a strip one foot wide that will reach around the world at the equator a total of 67 times.

SOAKING PITS

By G. R. McDERMOTT
Vice President, Surface Combustion Corporation, Chapman-Stein Division, Toledo, Ohio

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Paper presented before the A. I. & S. E. E. Spring Engineering Conference held in Youngstown, Ohio, April 24 and 25.

At the June, 1930, Convention of this Association, held in Buffalo, we had the privilege of reading a paper covering developments in industrial furnace design as applied to the steel industry and we dwelt somewhat on the subject of soaking pits and the one-way-fired or refractory recuperative pit, in particular.

Since that time additional installations have been made—in some cases in the rebuilding of regenerative pits to the one-way-fired pit and also complete new installations. The fuels used have been general in their kind, such as coke-oven gas, producer gas, natural gas, refinery gas and fuel oil. The most recent installation is two four-batteries for one of the Eastern plants where oil is the fuel in use.

It is perhaps permissible to review the fundamental principle of design of the one-way-fired pit, which has since been so universally accepted by the trade as a step forward in the economic and quality heating of ingots.

The firing ports of the one-way-fired pits are located in one of the end walls and the products of combustion or flame is developed in a combustion space immediately above the ingots to be heated. The ingots are usually arranged in two rows along the longitudinal axis of the pit, usually from two to four ingots per row, depending on the size of ingots charged.

The hot products of combustion are delivered in part to the far wall of the pit where they turn downward between the ingots, reverse their direction and leave the pit through suitable waste gas outlets to the recuperator. Such a design permits the selection of a firing port suitable for the particular fuel to be used, thereby providing for maximum combustion efficiency.

The intensity of draft imposed on each hole of the battery is controlled by a suitable damper installed immediately after each recuperator of each hole of the battery. The operator thereby may regulate the rate of firing and also the distribution of products of combustion by the amount of draft imposed on the hole, i.e. the products of combustion assume a horizontal horseshoe path and the length of the horseshoe is controlled by the draft imposed.

In the case of the regenerative pit the firing port alternately becomes a combustion port and a waste gas port. Under such conditions the firing port then becomes a compromise from the standpoint of providing a port design for maximum combustion efficiency.

Due to the more efficient construction, it is possible to operate close to the theoretical air required for a given fuel. This, of course, has a direct bearing on the scale loss. The particular port design in use adapts itself to a change of fuel without involving very much expense or time in making the changeover.

It is interesting to note that when it is necessary to hold steel in the pits at or near rolling temperature, actual practice has demonstrated that ingots may be held three and a half to four hours in the one-way-fired pits, as compared with two hours in the reversing pit. This was not peculiar to a particular installation but was true for other installations where a comparison was possible. Ingots held in the two types of pits indicated a reduction in the scale formation in the one-way-fired pit during the holding period which we believe demonstrates the relative merits of the two designs with respect to air leakage and radiation losses.

When it is taken into consideration that the refractory mass of regenerator checkers is about 200% greater than that represented by the refractory mass of the recuperator for pits of the same size, the results mentioned above are rather surprising. However, the top pass of the tile recuperator is approximately at the temperature of the outlet waste gases, while on the other hand the checkers on the firing end will vary from 1400° to 1800° F., depending on the reversing cycle. It is then apparent that there will be a transfer of heat from the pit walls and steel to the colder regenerator chamber until reduced temperature equilibrium is reached.

Furthermore, since there exists this compromise of alternating the waste gas and combustion port, it necessarily means that the waste gas port is located well below the top of the ingots with the result that when used as a firing port the flames of combustion impinge upon the ingot surfaces. It will then be readily appreciated by those familiar with the heating of ingots the extreme care which must be taken to prevent damage to the ingot surface by overheating. This is particularly true when thin-skinned, high carbon and alloy steels are heated. When the combustion takes place above the steel, as it does in the case of the one-way-fired pits, the possibility of

burning the steel has been reduced to a minimum. As mentioned before, one of the recent installations provides for fuel oil firing and it is on account of the principle of design that the application of fuel oil is a success as a soaking pit fuel. The use of fuel oil for regenerative or reversing pits has been rather limited, and then only in the case of emergency, on account of the harsh characteristic of the flame.

There is another important feature which we desire to mention and that is the relative space requirements for the same heating capacity when comparing the two types of design. As a typical example we refer to one of our installations where five blocks of pits were installed in the extension of an existing pit building. If the original regenerative pits had been installed in the extension, the total ingot capacity would have been 176 ingots in 44 holes, each hole 6'6"x7'9" and ingot size 27"x27", the total length of building would have been 575'0". On the supposition that the one-way-fired pit had been available at the conception of this particular mill, it would have been possible to install 44 holes, each hole 7'2"x13'0", having a total ingot capacity of 343 27"x27" ingots in the same building dimensions, or considering it from the standpoint of existing capacity, it would have been possible to have installed the present capacity as represented by five four-hole one-way-fired pits and four four-hole regenerator pits of the above size of holes in a pit building 364'0" long as compared with the existing building which is about 468'0" long, or a reduction of 104'0".

We have been giving considerable thought recently to automatic temperature control of ingot heating. It is true that pit operators from experience become quite proficient in their judgment of the proper ingot temperature for rolling. However, considering the narrow range of heating temperature requirements for different chemical analysis it would seem that reliance to the heater's eye without the constant use of pyrometric control has some hazards. To illustrate, we give below a heating schedule in use at one of the prominent steel plants:

Carbon Range	Manganese	Temperature
.06 – .12 to .50 – 1.20	25 – 60	2350°F. to 2175
.06 – .15	Phos. .06 – 1.00	2375
.04 – .06	Phos. .04 – .06	2350
.06 – .15	Sulphur .06 – 1.00	2400
.06 – .15	Sulphur .04 – .06	2350
.35 – 1.80	Silicon 1.00 and up Mang. .60 and up	2250
.06 – .15	Silicon 1.00 and up	1900
Ingot iron		2400

We are at present constructing two batteries of soaking pits at the Campbell Works of the Youngstown Sheet and Tube Company and in connection with one of the holes we are installing pyrometric equipment for automatically controlling the firing of the hole. This installation is more or less experimental as it is the first attempt, as far as we know, to control the heating of ingots in a soaking pit automatically by means of pyrometric equipment.

We are aware that recording pyrometers have been installed in connection with both regenerative and one-way-fired pits for recording pit temperatures. As a matter of fact, one of our recent installations is fully equipped with pyrometers for this purpose and others are following suit. The pyrometer couples are installed in the front wall, i.e. the wall opposite the burners. The temperature recorded is that of the pit or flame temperature, depending on whether the pit is being fired or is in the process of "soaking back," a term used when the ingot and pit are allowed to approach that of temperature equilibrium. This process continues until the ingot becomes ready for rolling. The equipment which is being installed at the Youngstown Sheet and Tube Company's plant consists of a Leeds and Northrup pyrometer which indicates and records the temperature of the ingot obtained by a radiation tube installed through the front wall of the pit. When "soaking back" the heater shuts off the fuel, the combustion air and closes the stack damper. This procedure usually occurs one to two hours before the ingot is drawn for rolling.

In the above is shown an illustration of a one-way fired soaking pit.

In all our installations we install a control board in connection with each hole. This board is provided with the necessary hand winches and position indicators for normally operating the fuel valve, air and individual stack dampers of the individual hole. In addition to this equipment for the trial installation, there will be a Leeds and Northrup recording pyrometer, two Stromberg time cycle clocks, one of which will be installed in the circuit of the small motor driving the air damper winch and the other in the motor circuit driving the individual stack damper.

In the gas line, between the manually controlled valve and the main gas supply header, there will be a motor operated gas valve. This valve will also be under the control of the Stromberg time cycle clocks. These clocks will permit "firing" and "soaking back" periods of varying amounts, depending upon their settings, which is under the control of the operator. These periods usually last from fifteen to twenty-five minutes, depending on how closely the time approaches for drawing the ingot. Limit switches are provided for returning the air and stack dampers to their previous or new positions as set by

the operator as determined by the rate of "firing." The pyrometer is equipped with a maximum temperature setting which will prevent opening of the motor operated gas valve when this temperature is reached.

It is to be noted that during the "soaking" period the temperature "indicated and recorded" will be that of the steel because during this period the fuel will be shut off while during the "firing" period the temperature will be that of the flame or steel, depending whether the pit atmosphere is clear of radiating gases in the vicinity of that portion of the ingot surface upon which the radiation pyrometer tube is sighted.

We regret that the time available when we were requested to present this paper on "soaking pits" was not sufficient for us to present results of the automatic temperature control as described. However, the apparatus is now being set up in our laboratory preparatory to being installed on the pits now being constructed. One block of four-holes is now in operation. The temperature control will be installed on one of the holes of the second block. We have endeavored to anticipate all the requirements for such a control and no doubt changes will have to be made before the objective is attained. We hope that when this time arrives that we will be given the privilege of presenting the results at a later meeting of the Society.

DISCUSSION

Discussion presented by

M. J. Conway, Fuel Engineer, Lukens Steel Company, Coatesville, Pa.

G. D. Mantle, Pittsburgh District Manager, Surface Combustion Corporation.

M. J. Bradley, Combustion Engineer, Leeds & Northrup Company, Philadelphia, Pa.

L. F. Coffin, Supt. of Mech. Dept., Bethlehem Steel Company, Sparrows Point, Md.

T. J. Ess, Combustion Engineer, Republic Steel Corporation, Massillon, Ohio.

M. J. Conway: I have a question to ask. Ignoring for the moment the other excellent features of the one-way-fired soaking pit, what percentage of fuel saving has been found in practice to be directly attributed to changing from a regenerative pit to a recuperative pit?

G. D. Mantle: It is pretty hard to give a figure because of the temperature of the steel, method of operation, and so on, but the reduction will be about 30 per cent.

M. J. Bradley: Mr. McDermott's paper deals with one of the more important steps in the production of steel. In the soaking pit the quality of steel may be improved or ruined, depending upon many operating conditions. It is not necessary, at this time, to discuss the effects of under-heating, over-heating, uneven heating, or burning of the ingot. It is agreed generally that there is an optimum temperature to which an ingot should be uniformly heated before starting the mechanical working. On high carbon ingots and especially on some alloy ingots it is not only necessary to have the ingot uniformly heated to a definite temperature before working, but it is important also that the rate of heating be controlled. This means that the difference in temperature between the soaking pit and the ingot, or the heat pressure around the ingot must be regulated within limits to prevent cracking and distortion. The combustion conditions determine to a great extent the heating rate and the atmosphere conditions within the pit. On many old pits the heater has very little control over any of these conditions. On pits which have been installed recently, provision is made in the original design for controlling these conditions.

Let me refer for a moment, if you please, to the heat treating of carbon and alloy steels. We find that in the automobile industry many years of development in methods of heating, control of heating, control of temperature and atmosphere in the heating process, have been required to reach the present stage of accurate control over all conditions to obtain the present quality product. The same fundamental conditions are encountered in the soaking pit operation. The ingots certainly go through a lot of mechanical processing before the steel reaches the finished state. However, it is very important that the ingots be heated uniformly to the correct temperature before starting the mechanical work.

It is possible to control the temperature, the heating rate, and the pit atmosphere within reasonable limits. We believe that the development work now in operation will demonstrate many advantages to be obtained from controlled operation of soaking pits.

L. F. Coffin: I would like to ask the speaker whether they have any installations operating on straight blast furnace gas?

G. D. Mantle: No, we have not.

T. J. Ess: I would like to ask a question. What, if any, are the noticeable effects on surface of the steel heated in your recuperative pit as compared to the regenerative pit?

G. D. Mantle: The improvement on the surface of the steel of the pit is most marked. There are quite a number of installations where there are a number of regenerative pits and one-way-fired pits in the same battery. With your back to the pits you can tell what comes from the one-way pit and what comes from the other pit. The surface is entirely different. As a matter of fact, in three or four cases I know of where a special quality of steel was being heated it was done only in the way-way-fired pits and not in the regenerative pit.

T. J. Ess: Is that true regardless of type of fuel?

G. D. Mantle: Absolutely.

DISCUSSION

(Continued from Page 341)

should be able to tell us what this fuel is worth in our furnaces. This is not only as a fuel cost alone but in probable improvements in mill operating practice and furnace repair and maintenance costs. It is their sales job and our responsibility to verify their sales claims.

There have been a number of furnaces where natural gas has been installed and where the gas companies we believe might enlighten themselves more thoroughly on the good qualities of their saleable product in order to present a better problem to a prospective consumer.

K. Emmerling: The steel plant operators will not very often give us the answer to that question. All that we can usually obtain is the fuel cost. It is almost impossible to get other items that go into the final cost of the product that are affected by the fuel used. Some of them are rather hard to determine accurately, as for instance, scale loss.

The fact remains, however, that if natural gas were not a satisfactory fuel, the furnaces that are on natural gas would have been changed to other fuels long ago.

J. L. Miller: Sometimes you can find that out if you have a will to. I realize that sometimes you get natural gas into a plant and it stays in because there is a good gas producer as a club to keep things in line. Sometimes there is a gas producer plant that needs rejuvenating and there is not much of a club.

K. Emmerling: That may be. I don't know about that.

H. V. Flagg: Mr. Miller's point seems to me well taken.

So far as the idea is concerned of applying natural gas to an ordinary producer gas fired reheating furnace, which has been giving the performance ordinarily expected from this type of furnace, under its usual limitations of fuel quality and furnace control, I would like to make the point that had the same degree of skill and experience been devoted to improving gas producer practice and furnace application as was involved in the natural gas application, comparable furnace performance might have been secured at still lower fuel cost. On the other hand, I can cite from my own experience applications where an ordinary natural gas application gives better results than any other of the ordinary fuels no matter what pains or expense are taken with the application.

I think we will all agree that if an adequate supply of natural gas were available at a cost comparable to that of other steel mill fuels, this fuel would find universal use.

F. B. Jones: I would like to add one more word on the question of gas companies working with the steel companies somewhat along the line on which Mr. Emmerling has spoken. We realize that we can accomplish more by working with the steel companies on the basis of co-operation. Our engineers are not supermen and we cannot always stand on the outside of your plant and predict just what results natural gas will give on particular operations within your plant. Of course, we have general cost data on the use of natural gas in various metal heating operations, but if you desire specific data on what natural gas will do for you on your own heating operations, then the best place to get that data is in your own plant. I think you are entitled to such data if you need it to solve a fuel or heating problem. If you do need such data, then we must have an opportunity to seek such data in your own mill. We are ready and anxious to co-operate with you in such work and I believe that in most problems a solution can be found that will be mutually beneficial.

ITEMS OF INTEREST

Col. William R. Dunlap has been appointed the public relations director of the Carnegie Steel Company, succeeding the late W. H. French. Colonel Dunlap was formerly city supplies director of the city of Pittsburgh.

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At a recent meeting of the board of directors of the Combustion Engineering Company, Inc., F. H. Rosencrants was elected a vice president, effective June 1, 1935. He will assume charge of the Proposition Engineering Department.

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The C. J. Tagliabue Mfg. Co., Brooklyn, N. Y., manufacturers of Temperature, Pressure, Flow, Humidity, Time and Level Instruments, announces the appointment of E. D. Wacker as assistant general sales manager.

Mr. Wacker has been with the company for 11 years, part of the time as manager of the Pittsburgh territory and more recently as division sales manager in charge of Snapon Controller Sales for domestic refrigerators.

The company also announces that the sales of the Snapon Controller Division will be in charge of R. A. Skinner.

▲

Roy C. Kendall has been appointed general sales manager of The Medart Company, his appointment being effective as of May 13. Mr. Kendall formerly represented The Medart Company in the State of Wisconsin. Previous to his becoming associated with Medart, he was connected with the Link Belt Company for more than fifteen years.

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H. F. Boe has been appointed assistant Eastern district manager of the Westinghouse Electric and Manufacturing Company with headquarters at Rockefeller Center, New York City.

Arthur H. Young, vice president in charge of industrial relations, United States Steel Corporation, who is to be one of the leading speakers at our con-

ARTHUR H. YOUNG

vention in September, was awarded the Henry Lawrence Gantt medal in recognition of his meritorious work in the field of industrial relations at a dinner of the Institute of Management, May 24.

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Kendall A. Redfield, advertising manager of the Rockbestos Products Corporation, New Haven, Conn., manufacturers of asbestos insulated electrical wires and cables, has been made assistant general sales manager. Herbert O. Anderson is general sales manager.

Mr. Redfield will continue to supervise the advertising and promotion program of the company.

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L. W. Lyons, widely known in the industrial world, was recently elected treasurer of the Westinghouse Electric and Manufacturing Company, succeeding former Treasurer Herman F. Baetz, who is retiring from active duty.

Joining Westinghouse in 1904, Mr. Lyons has continuously been a member of the Credit Department and for many years prior to his election as treasurer served as manager of this important department. He has also held the positions of assistant secretary and assistant treasurer. His career has been that of a specialist in credit problems and accounting procedure of a nature encountered in a large corporation doing business internationally.

▲

The honorary degree of Doctor of Mining Engineer was conferred on Charles R. Hook, president of The American Rolling Mill Company, by the Michigan College of Mining and Technology, at Houghton, Mich., for his contribution to the development of the iron and steel industry.

After graduating from high school, Mr. Hook became an apprentice roll turner in the steel mills. He joined The American Rolling Mill organization 32 years ago as night superintendent, and in 1904 introduced what is believed to be the first of the modern plans of employee representation in American industry. Mr. Hook was a pioneer among business executives to advocate taking the mystery out of business by taking employees into the confidence of the management.

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The Brown Instrument Company, Philadelphia, Pa., manufacturers of instruments and controls, and the Minneapolis-Honeywell Regulator Company, Minneapolis, Minn., manufacturers of control systems and regulators, have opened a joint office at 303—the 101 Marietta Street Building, Atlanta, Ga., to serve the Southeast.

Wesley R. Moore, for a number of years district manager of Brown Instrument Company, is manager in charge, with Leon L. Kuempel, sales engineer, Charles A. Kitzinger, service engineer, and J. A. Crawley, office manager.

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Colonel J. S. Ervin, president of the Mackintosh-Hemphill Company, has just announced the establishment of a finishing machinery division for the company and the appointment of Frank H. Streine, veteran designer and builder of finishing machinery, to be head of the division. Mr. Streine was for years vice president and general manager of the Streine Tool and Manufacturing Company, and more recently president of the Mill Equipment Company.

FRANK H. STREINE

The man who heads the new division has been one of the leading figures in the finishing machinery field for 20 years. He designed and built types of finishing machinery which are now in use in the plants of United States Steel subsidiaries, Bethlehem, Youngstown, American Rolling Mills, and many other steel companies.

Mr. Streine was originally engaged in the machine tool business in Cincinnati. He went into the business of building steel finishing machinery in 1914 and he was one of the organizers of the Streine company in 1917. He continued in active direction of that company until last year.

The finishing machinery end of the Mackintosh-Hemphill business will be carried on at the company's plants at Pittsburgh and Midland, Pa., and in particular at Wooster, O. The Wooster plant already contains equipment for the construction of all types of heavy machinery and can be put into immediate operation on the new types of machinery.

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Announcement is made by the Harnischfeger Corporation of Milwaukee of the appointment of Charles W. Daniels as general sales manager for the entire line of P&H contractors' equipment, industrial products, P&H-Hansen Arc Welders, hoists, brewery equipment, etc.

ADVERTISING PAGES REMOVED

Mr. Daniels, who has been connected with Harnischfeger for many years in various capacities, was for several years in New York, but most recently in charge of the corporation's Philadelphia office. He has already been transferred to the home office in Milwaukee to assume active charge of the sales for the various manufacturing divisions. He is succeeded in Philadelphia by L. M. Stout, who has been appointed to fill the vacancy as district manager for that territory.

WITH THE MANUFACTURERS

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An oil blast circuit breaker especially applicable where space is limited, such as in industrial plants and other stations, has been announced by the General Electric Company. Designated as Type FK-42, it is rated 600 amperes, 7500 volts; 800 amperes, 2500 volts, and 25,000 kv-a. interrupting rating. All designs are double and triple-pole single throw, with all poles in a single rectangular welded plate steel tank. Provision is made for mounting directly back of panels, or in switch houses or metal-enclosed switchgear. They may be manually or electrically operated.

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Announced June 1 by the New Departure Manufacturing Company, Bristol, Conn., is a new product of their manufacture called the "New Departure Variable Speed Transitorq." It is an integral unit consisting of a constant speed electric motor and a variable speed transmission device.

This unit is built with speed ranges of 6:1 and speed selectivity may be obtained either before starting the unit or while running. Starting and stopping is always at the low speed, high torque rating of the unit. This unit may be mounted horizontally or vertically and is adaptable to any make of motor. Full details of ratings, construction, etc., of the "Transitorq" may be obtained from the New Departure Company upon request.

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The Trumbull Electric Mfg. Co., Plainville, Conn., announce a new Front Operated 7½ H.P. Manual Motor Starter, Type "TM-7½". This starter which is "Across-the-line type" with silver to silver contacts provides thermostatic overload protection by interchangeable heater units.

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Electrical Engineers Equipment Company, Melrose Park, Ill., have just published a new booklet No. 321 on Group Operated Air Break Switches built to N.E.M.A. standards regarding insulators, clearances, etc. These switches are priced in capacities from 7.5 to 161 Kv., and the bulletin also includes prices and information regarding manual and motor operating mechanisms.

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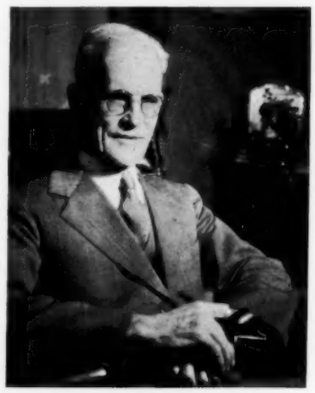
About a year ago, H. O. Swoboda, Inc., Pittsburgh, Pa., pioneered in the development and construction of electric heaters for local stress relieving of welded seams in large penstocks, pressure vessels, etc.

Announcement is being made at this time of a complete line of electric heaters for stress relieving welded seams in high pressure piping, nozzle attachments, etc.

The necessity for stress relieving is well recognized, and "Falcon" heaters are designed to take care of the complete range of sizes from high pressure piping to large penstocks, pressure vessels, etc. Additional information, photographs, etc., will be furnished to interested parties.

OBITUARIES

John Robert Penman, Electrical Engineer, Reading Iron Company, Reading, Pa., and long an active member of the A. I. & S. E. E., died at his home in Reading, Pa., May 19.



JOHN ROBERT PENMAN

Mr. Penman had a long and commendable record in the steel industry in the eastern part of this country. In earlier life he had been associated with the General Electric Company and had assisted in the installation of the first electric car on the streets of Philadelphia. At this time the membership of the Society wishes to extend their deepest sympathies to the family and friends of Mr. Penman.

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C. O. Markhart, Engineer, Great Lakes Steel Corporation, Detroit, Mich., died May 15. The Society also wishes to extend its sympathies to the family and friends of Mr. Markhart who was a member.

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Henry F. Wanning, Director and member of Executive Committee of Farrel-Birmingham Company, Inc., and President of former Birmingham Iron Foundry, died April 28.

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The Rollway Bearing Company, Syracuse, N. Y., wishes to announce the death, April 22, of J. D. Firmin, their Philadelphia representative.

Mr. Firmin joined the Westinghouse Company first after graduation from Purdue University, and then in 1904 went with the Niles Bement Pond Company. He remained until 1925 with the latter, spending most of his time at their plant in Philadelphia, but superintending the erection of a South American plant for them between 1918 and 1921.

From 1925 until his decease, he was with the Rollway Bearing Company, doing the engineering and sales work in a large territory having Philadelphia as its center.